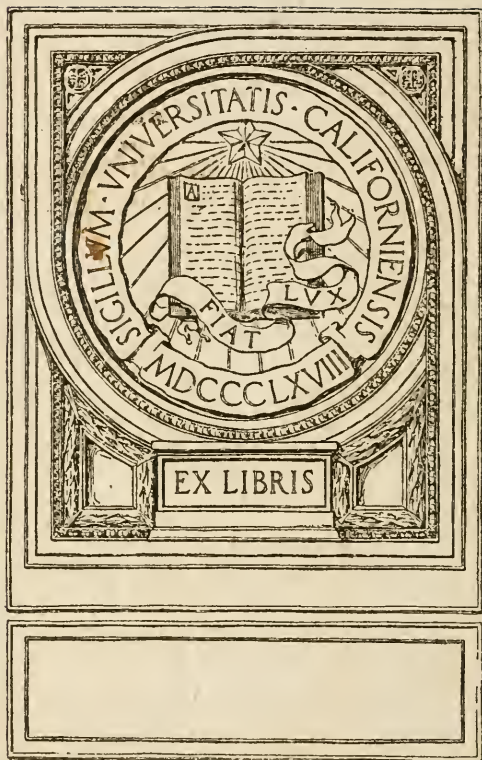



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MATHEMATICAL TEXTS FOR ENGINEERING STUDENTS
EDITED BY MANSFIELD MERRIMAN

MATHEMATICAL TABLES

FOR

CLASS-ROOM USE

BY
MANSFIELD MERRIMAN

EDITOR-IN-CHIEF OF AMERICAN CIVIL ENGINEERS' POCKET BOOK
MEMBER OF AMERICAN MATHEMATICAL SOCIETY

FIRST EDITION

FIRST THOUSAND

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PREFACE

Computations of squares, square roots, reciprocals, areas of circles, and other functions of numbers occur in the daily work of every student of technology. This book gives four-place tables by which the time spent in such computations can be much shortened. Tables of trigonometric functions, of logarithms, and of weights and measures are also given. These will be found useful in cases where a high degree of precision is not required, namely, in the great majority of problems that arise in physics and engineering.

These tables have been taken from the American Civil Engineers' Pocket Book, and hence have a form which is approved in the work of practical computation. It is believed that they will be of value to students in blackboard work, in the examination room, in the field and laboratory, and in the drawing room, as well as in the solution of text-book problems.

Explanations, prepared especially for this volume, will render the use of the tables easily understood, and these are accompanied by remarks regarding the degree of precision to be expected in interpolated tabular values. Exercises for students are given at the end of each chapter. It is hoped that this little book may assist both teachers and students in saving time and labor, and thus tend to promote economy and efficiency.

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CHAPTER 1

GENERAL EXPLANATIONS

1. Arguments and Functions

Arguments and Functions are the two kinds of numbers that appear in a table, the former being the numbers which are given and the latter those which are sought. The arguments are the numbers for which the values of the functions have been computed; thus in \sqrt{n} , values of n are the arguments and those of \sqrt{n} are the functions. An argument is at the side of the table, or sometimes part of it is at the side and part at the top or foot; thus when the square of 6.48 is sought from Table 7, the number 6.4 is found at the left-hand side of the table and the 8 at the top or foot, then at the intersection of the horizontal row and the vertical column is found the function or number 41.99 which is the square of 6.48 correct to four places. In the tables of this book the arguments are generally in bold-face type and the functions in common type.

2. Precision of Tabular Values

The values of the functions in many of the tables of this book are generally given only to four significant figures; thus the square of 7.54 is given as 56.85, although its exact value is 56.8516. The greater part of the computations in physics and engineering require only three or four significant figures to be determined with precision, since the given data rarely extend with accuracy to a greater number of figures.

Significant figures in a number are those not preceded by ciphers after a decimal point. For example, each of the numbers 4507, 4.507, 0.04507 and 0.0004507 has four significant figures; the number 30.2734 has six significant figures, while 0.065 and 6.5 have only two.

In any table the last figure of the argument is exact, but the last figure of the function is liable to an error. Thus, when the computed value of a function is 42.7854, the value given in a four-place table is 42.79, the last figure having here an error of nearly one-half of a unit; when the computed value is 3.7851 the value given in a four-place table is 3.785, the last figure having here an

error of one-tenth of a unit. The maximum error in a tabulated function is hence one-half a unit in the last figure, and the probable error is one-fourth of a unit.

3. Interpolation

Interpolation is the process of finding the value of a function when the given argument lies between two tabular arguments. This is generally done by regarding the function as varying uniformly between the two adjacent tabular values. For example, if it be required to find the reciprocal of 0.2645 from Table 6, it is seen that the reciprocals of 0.264 and 0.265 are 3.788 and 3.774; hence the reciprocal of 0.2645 is half-way between these, or 3.781. Again, let it be required to find the square root of 85.04 from Table 8; the square roots of 85.0 and 85.1 are found to be 9.220 and 9.225; the difference of these is 0.005, and 0.4×0.005 is 0.002; then the square root of 85.04 is $9.220 + 0.002 = 9.222$. After a little practise interpolation in a four-place table can be made mentally.

As another example, let it be required to find the value of $\sin 43^\circ 4'$ from Table 25; here the sines of $43^\circ 0'$ and $43^\circ 10'$ are 0.68200 and 0.68412, the difference of which is 0.00212, thus the difference for $1'$ is 0.000212 and for $4'$ it is 0.00085; then $\sin 43^\circ 4'$ is $0.68200 + 0.00085 = 0.68285$. When the function decreases as the argument increases, the computed difference is to be subtracted from the greater value of the function; thus to find the reciprocal of 0.5427, the reciprocals of 0.542 and 0.543 are 1.845 and 1.842; the difference of these is 0.003, and $0.003 \times 0.7 = 0.002$; hence the reciprocal of 0.5427 is $1.845 - 0.002 = 1.843$.

The precision of an interpolated value is less than that of the tabular values, because the assumption that the function varies uniformly between the two adjacent tabular values is not strictly correct, and because it is obtained by taking the difference of two tabular values which are not exact in the last figure. In general the probable error in an interpolated value is at least one-half a unit in the last figure.

Inverse interpolation is the process of obtaining an argument

from a given function when the latter lies between two adjacent tabular values; this will be explained in Arts. 28 and 34.

4. Precision of Computed Results

It is important that a computer should use the tables so as to obtain the most precise result possible and also that he should not attribute to the result a precision which does not exist. In general no more than four significant figures can be obtained from a four-place table, and in the case of extended computations the last figure may be liable to an error of one unit. For example, the value of $\sqrt{6.3^2 + 8.4^2}$ is found by the help of Tables 7 and 8 to be 10.50, which is exact, but the value of $(1.25^2 + 1.45^2)^2$ is found to be 13.44, which is one unit in error in the last figure.

Inexperienced computers sometimes, in making interpolations, use all the figures obtained in the multiplication of differences, and thus carry the work several places further than the tabular values warrant. This procedure not only entails additional work and gives extra figures which are wholly inaccurate, but it leads the computer to suppose that his results have a far higher degree of precision than is actually the case, hence vitiating his judgment and perhaps leading to the deceit of others as well as of himself. In no case should more significant figures appear in the final results than are given in the tables which are used.

5. Exercises for Students

1. From Table 6 obtain the reciprocals of 0.76, 0.765, 0.766, 0.7665, 0.7668, also the reciprocals of 5.5, 5.53, 5.534, 5.536.
2. From Table 7 obtain the four-place squares of 1.85 and 1.86; verify the results by actual multiplications.
3. From Table 7 obtain the squares of 8.5, 8.53, 8.534; also of 0.85, 0.853, 0.8534.
4. Find the sine of $18^\circ 23'$ from Table 25.
5. Find the value of $(3.27^2 + 4.18^2)^2$ by the help of Table 7; compare it with the result obtained by actual multiplication.
6. Find the square roots of 6.35 and 63.5 from Table 8; also the square roots of 6.352 and 65.32.
7. Find the values of $1.42^{\frac{3}{2}}$ and $1.524^{\frac{3}{2}}$ from Table 11.

CHAPTER 2

ARITHMETICAL TABLES

Explanation on p. 38

<i>n</i>	0	1	2	3	4	5	6	7	8	9
0.10	10.00	9.901	9.804	9.709	9.615	9.524	9.434	9.346	9.259	9.174
0.11	9.091	9.009	8.929	8.850	8.772	8.696	8.621	8.547	8.475	8.403
0.12	8.333	8.264	8.197	8.130	8.065	8.000	7.937	7.874	7.813	7.752
0.13	7.692	7.634	7.576	7.519	7.463	7.407	7.353	7.299	7.246	7.194
0.14	7.143	7.092	7.042	6.993	6.944	6.897	6.849	6.803	6.757	6.711
0.15	6.667	6.623	6.579	6.536	6.494	6.452	6.410	6.369	6.329	6.289
0.16	6.250	6.211	6.173	6.135	6.098	6.061	6.024	5.988	5.952	5.917
0.17	5.882	5.848	5.814	5.780	5.747	5.714	5.682	5.650	5.618	5.587
0.18	5.556	5.525	5.495	5.464	5.435	5.405	5.376	5.348	5.319	5.291
0.19	5.263	5.236	5.208	5.181	5.155	5.128	5.102	5.076	5.051	5.025
0.20	5.000	4.975	4.950	4.926	4.902	4.878	4.854	4.831	4.808	4.785
0.21	4.762	4.739	4.717	4.695	4.673	4.651	4.630	4.608	4.587	4.566
0.22	4.545	4.525	4.505	4.484	4.464	4.444	4.425	4.405	4.386	4.367
0.23	4.348	4.329	4.310	4.292	4.274	4.255	4.237	4.219	4.202	4.184
0.24	4.167	4.149	4.132	4.115	4.098	4.082	4.065	4.049	4.032	4.016
0.25	4.000	3.984	3.968	3.953	3.937	3.922	3.906	3.891	3.876	3.861
0.26	3.846	3.831	3.817	3.802	3.788	3.774	3.759	3.745	3.731	3.717
0.27	3.704	3.690	3.676	3.663	3.650	3.636	3.623	3.610	3.597	3.584
0.28	3.571	3.559	3.546	3.534	3.521	3.509	3.497	3.484	3.472	3.460
0.29	3.448	3.436	3.425	3.413	3.401	3.390	3.378	3.367	3.356	3.344
0.30	3.333	3.322	3.311	3.300	3.289	3.279	3.268	3.257	3.247	3.236
0.31	3.226	3.215	3.205	3.195	3.185	3.175	3.165	3.155	3.145	3.135
0.32	3.125	3.115	3.106	3.096	3.086	3.077	3.067	3.058	3.049	3.040
0.33	3.030	3.021	3.012	3.003	2.994	2.985	2.976	2.967	2.959	2.950
0.34	2.941	2.933	2.924	2.915	2.907	2.899	2.890	2.882	2.874	2.865
0.35	2.857	2.849	2.841	2.833	2.825	2.817	2.809	2.801	2.793	2.786
0.36	2.778	2.770	2.762	2.755	2.747	2.740	2.732	2.725	2.717	2.710
0.37	2.703	2.695	2.688	2.681	2.674	2.667	2.660	2.653	2.646	2.639
0.38	2.632	2.625	2.618	2.611	2.604	2.597	2.591	2.584	2.577	2.571
0.39	2.564	2.558	2.551	2.545	2.538	2.532	2.525	2.519	2.513	2.506
0.40	2.500	2.494	2.488	2.481	2.475	2.469	2.463	2.457	2.451	2.445
0.41	2.439	2.433	2.427	2.421	2.415	2.410	2.404	2.398	2.392	2.387
0.42	2.381	2.375	2.370	2.364	2.358	2.353	2.347	2.342	2.336	2.331
0.43	2.326	2.320	2.315	2.309	2.304	2.299	2.294	2.288	2.283	2.278
0.44	2.273	2.268	2.262	2.257	2.252	2.247	2.242	2.237	2.232	2.227
0.45	2.222	2.217	2.212	2.208	2.203	2.198	2.193	2.188	2.183	2.179
0.46	2.174	2.169	2.165	2.160	2.155	2.151	2.146	2.141	2.137	2.132
0.47	2.128	2.123	2.119	2.114	2.110	2.105	2.101	2.096	2.092	2.088
0.48	2.083	2.079	2.075	2.070	2.066	2.062	2.058	2.053	2.049	2.045
0.49	2.041	2.037	2.033	2.028	2.024	2.020	2.016	2.012	2.008	2.004
0.50	2.000	1.996	1.992	1.988	1.984	1.980	1.976	1.972	1.969	1.965
0.51	1.961	1.957	1.953	1.949	1.946	1.942	1.938	1.934	1.931	1.927
0.52	1.923	1.919	1.916	1.912	1.908	1.905	1.901	1.898	1.894	1.890
0.53	1.887	1.883	1.880	1.876	1.873	1.869	1.866	1.862	1.859	1.855
0.54	1.852	1.848	1.845	1.842	1.838	1.835	1.832	1.828	1.825	1.821
<i>n</i>	0	1	2	3	4	5	6	7	8	9

of Numbers

<i>n</i>	0	1	2	3	4	5	6	7	8	9
0.55	1.818	1.815	1.812	1.808	1.805	1.802	1.799	1.795	1.792	1.789
0.56	1.786	1.783	1.779	1.776	1.773	1.770	1.767	1.764	1.761	1.757
0.57	1.754	1.751	1.748	1.745	1.742	1.739	1.736	1.733	1.730	1.727
0.58	1.724	1.721	1.718	1.715	1.712	1.709	1.706	1.704	1.701	1.698
0.59	1.695	1.692	1.689	1.686	1.684	1.681	1.678	1.675	1.672	1.669
0.60	1.667	1.664	1.661	1.658	1.656	1.653	1.650	1.647	1.645	1.642
0.61	1.639	1.637	1.634	1.631	1.629	1.626	1.623	1.621	1.618	1.616
0.62	1.613	1.610	1.608	1.605	1.603	1.600	1.597	1.595	1.592	1.590
0.63	1.587	1.585	1.582	1.580	1.577	1.575	1.572	1.570	1.567	1.565
0.64	1.562	1.560	1.558	1.555	1.553	1.550	1.548	1.546	1.543	1.541
0.65	1.538	1.536	1.534	1.531	1.529	1.527	1.524	1.522	1.520	1.517
0.66	1.515	1.513	1.511	1.508	1.506	1.504	1.502	1.499	1.497	1.495
0.67	1.493	1.490	1.488	1.486	1.484	1.481	1.479	1.477	1.475	1.473
0.68	1.471	1.468	1.466	1.464	1.462	1.460	1.458	1.456	1.453	1.451
0.69	1.449	1.447	1.445	1.443	1.441	1.439	1.437	1.435	1.433	1.431
0.70	1.429	1.427	1.425	1.422	1.420	1.418	1.416	1.414	1.412	1.410
0.71	1.408	1.406	1.404	1.403	1.401	1.399	1.397	1.395	1.393	1.391
0.72	1.389	1.387	1.385	1.383	1.381	1.379	1.377	1.376	1.374	1.372
0.73	1.370	1.368	1.366	1.364	1.362	1.361	1.359	1.357	1.355	1.353
0.74	1.351	1.350	1.348	1.346	1.344	1.342	1.340	1.339	1.337	1.335
0.75	1.333	1.332	1.330	1.328	1.326	1.325	1.323	1.321	1.319	1.318
0.76	1.316	1.314	1.312	1.311	1.309	1.307	1.305	1.304	1.302	1.300
0.77	1.299	1.297	1.295	1.294	1.292	1.290	1.289	1.287	1.285	1.284
0.78	1.282	1.280	1.279	1.277	1.276	1.274	1.272	1.271	1.269	1.267
0.79	1.266	1.264	1.263	1.261	1.259	1.258	1.256	1.255	1.253	1.252
0.80	1.250	1.248	1.247	1.245	1.244	1.242	1.241	1.239	1.238	1.236
0.81	1.235	1.233	1.232	1.230	1.229	1.227	1.225	1.224	1.222	1.221
0.82	1.220	1.218	1.217	1.215	1.214	1.212	1.211	1.209	1.208	1.206
0.83	1.205	1.203	1.202	1.200	1.199	1.198	1.196	1.195	1.193	1.192
0.84	1.190	1.189	1.188	1.186	1.185	1.183	1.182	1.181	1.179	1.178
0.85	1.176	1.175	1.174	1.172	1.171	1.170	1.168	1.167	1.166	1.164
0.86	1.163	1.161	1.160	1.159	1.157	1.156	1.155	1.153	1.152	1.151
0.87	1.149	1.148	1.147	1.145	1.144	1.143	1.142	1.140	1.139	1.138
0.88	1.136	1.135	1.134	1.133	1.131	1.130	1.129	1.127	1.126	1.125
0.89	1.124	1.122	1.121	1.120	1.119	1.117	1.116	1.115	1.114	1.112
0.90	1.111	1.110	1.109	1.107	1.106	1.105	1.104	1.103	1.101	1.100
0.91	1.099	1.098	1.096	1.095	1.094	1.093	1.092	1.091	1.089	1.088
0.92	1.087	1.086	1.085	1.083	1.082	1.081	1.080	1.079	1.078	1.076
0.93	1.075	1.074	1.073	1.072	1.071	1.070	1.068	1.067	1.066	1.065
0.94	1.064	1.063	1.062	1.060	1.059	1.058	1.057	1.056	1.055	1.054
0.95	1.053	1.052	1.050	1.049	1.048	1.047	1.046	1.045	1.044	1.043
0.96	1.042	1.041	1.040	1.038	1.037	1.036	1.035	1.034	1.033	1.032
0.97	1.031	1.030	1.029	1.028	1.027	1.026	1.025	1.024	1.022	1.021
0.98	1.020	1.019	1.018	1.017	1.016	1.015	1.014	1.013	1.012	1.011
0.99	1.010	1.009	1.008	1.007	1.006	1.005	1.004	1.003	1.002	1.001
<i>n</i>	0	1	2	3	4	5	6	7	8	9

7. Squares of Num-

n	0	1	2	3	4	5	6	7	8	9
1.0	1.000	1.020	1.040	1.061	1.082	1.103	1.124	1.145	1.166	1.188
1.1	1.210	1.232	1.254	1.277	1.300	1.323	1.346	1.369	1.392	1.416
1.2	1.440	1.464	1.488	1.513	1.538	1.563	1.588	1.613	1.638	1.664
1.3	1.690	1.716	1.742	1.769	1.796	1.823	1.850	1.877	1.904	1.932
1.4	1.960	1.988	2.016	2.045	2.074	2.103	2.132	2.161	2.190	2.220
1.5	2.250	2.280	2.310	2.341	2.372	2.403	2.434	2.465	2.496	2.528
1.6	2.560	2.592	2.624	2.657	2.690	2.723	2.756	2.789	2.822	2.856
1.7	2.890	2.924	2.958	2.993	3.028	3.063	3.098	3.133	3.168	3.204
1.8	3.240	3.276	3.312	3.349	3.386	3.423	3.460	3.497	3.534	3.572
1.9	3.610	3.648	3.686	3.725	3.764	3.803	3.842	3.881	3.920	3.960
2.0	4.000	4.040	4.080	4.121	4.162	4.203	4.244	4.285	4.326	4.368
2.1	4.410	4.452	4.494	4.537	4.580	4.623	4.666	4.709	4.752	4.796
2.2	4.840	4.884	4.928	4.973	5.018	5.063	5.108	5.153	5.198	5.244
2.3	5.290	5.336	5.382	5.429	5.476	5.523	5.570	5.617	5.664	5.712
2.4	5.760	5.808	5.856	5.905	5.954	6.003	6.052	6.101	6.150	6.200
2.5	6.250	6.300	6.350	6.401	6.452	6.503	6.554	6.605	6.656	6.708
2.6	6.760	6.812	6.864	6.917	6.970	7.023	7.076	7.129	7.182	7.236
2.7	7.290	7.344	7.398	7.453	7.508	7.563	7.618	7.673	7.728	7.784
2.8	7.840	7.896	7.952	8.009	8.066	8.123	8.180	8.237	8.294	8.352
2.9	8.410	8.468	8.526	8.585	8.644	8.703	8.762	8.821	8.880	8.940
3.0	9.000	9.060	9.120	9.181	9.242	9.303	9.364	9.425	9.486	9.548
3.1	9.610	9.672	9.734	9.797	9.860	9.923	9.986	10.05	10.11	10.18
3.2	10.24	10.30	10.37	10.43	10.50	10.56	10.63	10.69	10.76	10.82
3.3	10.89	10.96	11.02	11.09	11.16	11.22	11.29	11.36	11.42	11.49
3.4	11.56	11.63	11.70	11.76	11.83	11.90	11.97	12.04	12.11	12.18
3.5	12.25	12.32	12.39	12.46	12.53	12.60	12.67	12.74	12.82	12.89
3.6	12.96	13.03	13.10	13.18	13.25	13.32	13.40	13.47	13.54	13.62
3.7	13.69	13.76	13.84	13.91	13.99	14.06	14.14	14.21	14.29	14.36
3.8	14.44	14.52	14.59	14.67	14.75	14.82	14.90	14.98	15.05	15.13
3.9	15.21	15.29	15.37	15.44	15.52	15.60	15.68	15.76	15.84	15.92
4.0	16.00	16.08	16.16	16.24	16.32	16.40	16.48	16.56	16.65	16.73
4.1	16.81	16.89	16.97	17.06	17.14	17.22	17.31	17.39	17.47	17.56
4.2	17.64	17.72	17.81	17.89	17.98	18.06	18.15	18.23	18.32	18.40
4.3	18.49	18.58	18.66	18.75	18.84	18.92	19.01	19.10	19.18	19.27
4.4	19.36	19.45	19.54	19.62	19.71	19.80	19.89	19.98	20.07	20.16
4.5	20.25	20.34	20.43	20.52	20.61	20.70	20.79	20.88	20.98	21.07
4.6	21.16	21.25	21.34	21.44	21.53	21.62	21.72	21.81	21.90	22.00
4.7	22.09	22.18	22.28	22.37	22.47	22.56	22.66	22.75	22.85	22.94
4.8	23.04	23.14	23.23	23.33	23.43	23.52	23.62	23.72	23.81	23.91
4.9	24.01	24.11	24.21	24.30	24.40	24.50	24.60	24.70	24.80	24.90
5.0	25.00	25.10	25.20	25.30	25.40	25.50	25.60	25.70	25.81	25.91
5.1	26.01	26.11	26.21	26.32	26.42	26.52	26.63	26.73	26.83	26.94
5.2	27.04	27.14	27.25	27.35	27.46	27.56	27.67	27.77	27.88	27.98
5.3	28.09	28.20	28.30	28.41	28.52	28.62	28.73	28.84	28.94	29.05
5.4	29.16	29.27	29.38	29.48	29.59	29.70	29.81	29.92	30.03	30.14
n	0	1	2	3	4	5	6	7	8	9

bers from 1.00 to 9.99

<i>n</i>	0	1	2	3	4	5	6	7	8	9
5.5	30.25	30.36	30.47	30.58	30.69	30.80	30.91	31.02	31.14	31.25
5.6	31.36	31.47	31.58	31.70	31.81	31.92	32.04	32.15	32.26	32.38
5.7	32.49	32.60	32.72	32.83	32.95	33.06	33.18	33.29	33.41	33.52
5.8	33.64	33.76	33.87	33.99	34.11	34.22	34.34	34.46	34.57	34.69
5.9	34.81	34.93	35.05	35.16	35.28	35.40	35.52	35.64	35.76	35.88
6.0	36.00	36.12	36.24	36.36	36.48	36.60	36.72	36.84	36.97	37.09
6.1	37.21	37.33	37.45	37.58	37.70	37.82	37.95	38.07	38.19	38.32
6.2	38.44	38.56	38.69	38.81	38.94	39.06	39.19	39.31	39.44	39.56
6.3	39.69	39.82	39.94	40.07	40.20	40.32	40.45	40.58	40.70	40.83
6.4	40.96	41.09	41.22	41.34	41.47	41.60	41.73	41.86	41.99	42.12
6.5	42.25	42.38	42.51	42.64	42.77	42.90	43.03	43.16	43.30	43.43
6.6	43.56	43.69	43.82	43.96	44.09	44.22	44.36	44.49	44.62	44.76
6.7	44.89	45.02	45.16	45.29	45.43	45.56	45.70	45.83	45.97	46.10
6.8	46.24	46.38	46.51	46.65	46.79	46.92	47.06	47.20	47.33	47.47
6.9	47.61	47.75	47.89	48.02	48.16	48.30	48.44	48.58	48.72	48.86
7.0	49.00	49.14	49.28	49.42	49.56	49.70	49.84	49.98	50.13	50.27
7.1	50.41	50.55	50.69	50.84	50.98	51.12	51.27	51.41	51.55	51.70
7.2	51.84	51.98	52.13	52.27	52.42	52.56	52.71	52.85	53.00	53.14
7.3	53.29	53.44	53.58	53.73	53.88	54.02	54.17	54.32	54.46	54.61
7.4	54.76	54.91	55.06	55.20	55.35	55.50	55.65	55.80	55.95	56.10
7.5	56.25	56.40	56.55	56.70	56.85	57.00	57.15	57.30	57.46	57.61
7.6	57.76	57.91	58.06	58.22	58.37	58.52	58.68	58.83	58.98	59.14
7.7	59.29	59.44	59.60	59.75	59.91	60.06	60.22	60.37	60.53	60.68
7.8	60.84	61.00	61.15	61.31	61.47	61.62	61.78	61.94	62.09	62.25
7.9	62.41	62.57	62.73	62.88	63.04	63.20	63.36	63.52	63.68	63.84
8.0	64.00	64.16	64.32	64.48	64.64	64.80	64.96	65.12	65.29	65.45
8.1	65.61	65.77	65.93	66.10	66.26	66.42	66.59	66.75	66.91	67.08
8.2	67.24	67.40	67.57	67.73	67.90	68.06	68.23	68.39	68.56	68.72
8.3	68.89	69.06	69.22	69.39	69.56	69.72	69.89	70.06	70.22	70.39
8.4	70.56	70.73	70.90	71.06	71.23	71.40	71.57	71.74	71.91	72.08
8.5	72.25	72.42	72.59	72.76	72.93	73.10	73.27	73.44	73.62	73.79
8.6	73.96	74.13	74.30	74.48	74.65	74.82	75.00	75.17	75.34	75.52
8.7	75.69	75.86	76.04	76.21	76.39	76.56	76.74	76.91	77.09	77.26
8.8	77.44	77.62	77.79	77.97	78.15	78.32	78.50	78.68	78.85	79.03
8.9	79.21	79.39	79.57	79.74	79.92	80.10	80.28	80.46	80.64	80.82
9.0	81.00	81.18	81.36	81.54	81.72	81.90	82.08	82.26	82.45	82.63
9.1	82.81	82.99	83.17	83.36	83.54	83.72	83.91	84.09	84.27	84.46
9.2	84.64	84.82	85.01	85.19	85.38	85.56	85.75	85.93	86.12	86.30
9.3	86.49	86.68	86.86	87.05	87.24	87.42	87.61	87.80	87.98	88.17
9.4	88.36	88.55	88.74	88.92	89.11	89.30	89.49	89.68	89.87	90.06
9.5	90.25	90.44	90.63	90.82	91.01	91.20	91.39	91.58	91.78	91.97
9.6	92.16	92.35	92.54	92.74	92.93	93.12	93.32	93.51	93.70	93.90
9.7	94.09	94.28	94.48	94.67	94.87	95.06	95.26	95.45	95.65	95.84
9.8	96.04	96.24	96.43	96.63	96.83	97.02	97.22	97.42	97.61	97.81
9.9	98.01	98.21	98.41	98.60	98.80	99.00	99.20	99.40	99.60	99.80
<i>n</i>	0	1	2	3	4	5	6	7	8	9

8. Square Roots of

<i>n</i>	0	1	2	3	4	5	6	7	8	9
1.0	1.000	1.005	1.010	1.015	1.020	1.025	1.030	1.034	1.039	1.044
1.1	1.049	1.054	1.058	1.063	1.068	1.072	1.077	1.082	1.086	1.091
1.2	1.095	1.100	1.105	1.109	1.114	1.118	1.122	1.127	1.131	1.136
1.3	1.140	1.145	1.149	1.153	1.158	1.162	1.166	1.170	1.175	1.179
1.4	1.183	1.187	1.192	1.196	1.200	1.204	1.208	1.212	1.217	1.221
1.5	1.225	1.229	1.233	1.237	1.241	1.245	1.249	1.253	1.257	1.261
1.6	1.265	1.269	1.273	1.277	1.281	1.285	1.288	1.292	1.296	1.300
1.7	1.304	1.308	1.311	1.315	1.319	1.323	1.327	1.330	1.334	1.338
1.8	1.342	1.345	1.349	1.353	1.356	1.360	1.364	1.367	1.371	1.375
1.9	1.378	1.382	1.386	1.389	1.393	1.396	1.400	1.404	1.407	1.411
2.0	1.414	1.418	1.421	1.425	1.428	1.432	1.435	1.439	1.442	1.446
2.1	1.449	1.453	1.456	1.459	1.463	1.466	1.470	1.473	1.476	1.480
2.2	1.483	1.487	1.490	1.493	1.497	1.500	1.503	1.507	1.510	1.513
2.3	1.517	1.520	1.523	1.526	1.530	1.533	1.536	1.539	1.543	1.546
2.4	1.549	1.552	1.556	1.559	1.562	1.565	1.568	1.572	1.575	1.578
2.5	1.581	1.584	1.587	1.591	1.594	1.597	1.600	1.603	1.606	1.609
2.6	1.612	1.616	1.619	1.622	1.625	1.628	1.631	1.634	1.637	1.640
2.7	1.643	1.646	1.649	1.652	1.655	1.658	1.661	1.664	1.667	1.670
2.8	1.673	1.676	1.679	1.682	1.685	1.688	1.691	1.694	1.697	1.700
2.9	1.703	1.706	1.709	1.712	1.715	1.718	1.720	1.723	1.726	1.729
3.0	1.732	1.735	1.738	1.741	1.744	1.746	1.749	1.752	1.755	1.758
3.1	1.761	1.764	1.766	1.769	1.772	1.775	1.778	1.780	1.783	1.786
3.2	1.789	1.792	1.794	1.797	1.800	1.803	1.806	1.808	1.811	1.814
3.3	1.817	1.819	1.822	1.825	1.828	1.830	1.833	1.836	1.838	1.841
3.4	1.844	1.847	1.849	1.852	1.855	1.857	1.860	1.863	1.865	1.868
3.5	1.871	1.873	1.876	1.879	1.881	1.884	1.887	1.889	1.892	1.895
3.6	1.897	1.900	1.903	1.905	1.908	1.910	1.913	1.916	1.918	1.921
3.7	1.924	1.926	1.929	1.931	1.934	1.936	1.939	1.942	1.944	1.947
3.8	1.949	1.952	1.954	1.957	1.960	1.962	1.965	1.967	1.970	1.972
3.9	1.975	1.977	1.980	1.982	1.985	1.987	1.990	1.992	1.995	1.997
4.0	2.000	2.002	2.005	2.007	2.010	2.012	2.015	2.017	2.020	2.022
4.1	2.025	2.027	2.030	2.032	2.035	2.037	2.040	2.042	2.045	2.047
4.2	2.049	2.052	2.054	2.057	2.059	2.062	2.064	2.066	2.069	2.071
4.3	2.074	2.076	2.078	2.081	2.083	2.086	2.088	2.090	2.093	2.095
4.4	2.098	2.100	2.102	2.105	2.107	2.110	2.112	2.114	2.117	2.119
4.5	2.121	2.124	2.126	2.128	2.131	2.133	2.135	2.138	2.140	2.142
4.6	2.145	2.147	2.149	2.152	2.154	2.156	2.159	2.161	2.163	2.166
4.7	2.168	2.170	2.173	2.175	2.177	2.179	2.182	2.184	2.186	2.189
4.8	2.191	2.193	2.195	2.198	2.200	2.202	2.205	2.207	2.209	2.211
4.9	2.214	2.216	2.218	2.220	2.223	2.225	2.227	2.229	2.232	2.234
5.0	2.236	2.238	2.241	2.243	2.245	2.247	2.249	2.252	2.254	2.256
5.1	2.258	2.261	2.263	2.265	2.267	2.269	2.272	2.274	2.276	2.278
5.2	2.280	2.283	2.285	2.287	2.289	2.291	2.293	2.296	2.298	2.300
5.3	2.302	2.304	2.307	2.309	2.311	2.313	2.315	2.317	2.319	2.322
5.4	2.324	2.326	2.328	2.330	2.332	2.335	2.337	2.339	2.341	2.343
<i>n</i>	0	1	2	3	4	5	6	7	8	9

Numbers from 1.00 to 99.9

Continued on p. 18

<i>n</i>	0	1	2	3	4	5	6	7	8	9
5.5	2.345	2.347	2.349	2.352	2.354	2.356	2.358	2.360	2.362	2.364
5.6	2.366	2.369	2.371	2.373	2.375	2.377	2.379	2.381	2.383	2.385
5.7	2.387	2.390	2.392	2.394	2.396	2.398	2.400	2.402	2.404	2.406
5.8	2.408	2.410	2.412	2.415	2.417	2.419	2.421	2.423	2.425	2.427
5.9	2.429	2.431	2.433	2.435	2.437	2.439	2.441	2.443	2.445	2.447
6.0	2.449	2.452	2.454	2.456	2.458	2.460	2.462	2.464	2.466	2.468
6.1	2.470	2.472	2.474	2.476	2.478	2.480	2.482	2.484	2.486	2.488
6.2	2.490	2.492	2.494	2.496	2.498	2.500	2.502	2.504	2.506	2.508
6.3	2.510	2.512	2.514	2.516	2.518	2.520	2.522	2.524	2.526	2.528
6.4	2.530	2.532	2.534	2.536	2.538	2.540	2.542	2.544	2.546	2.548
6.5	2.550	2.551	2.553	2.555	2.557	2.559	2.561	2.563	2.565	2.567
6.6	2.569	2.571	2.573	2.575	2.577	2.579	2.581	2.583	2.585	2.587
6.7	2.588	2.590	2.592	2.594	2.596	2.598	2.600	2.602	2.604	2.606
6.8	2.608	2.610	2.612	2.613	2.615	2.617	2.619	2.621	2.623	2.625
6.9	2.627	2.629	2.631	2.632	2.634	2.636	2.638	2.640	2.642	2.644
7.0	2.646	2.648	2.650	2.651	2.653	2.655	2.657	2.659	2.661	2.663
7.1	2.665	2.666	2.668	2.670	2.672	2.674	2.676	2.678	2.680	2.681
7.2	2.683	2.685	2.687	2.689	2.691	2.693	2.694	2.696	2.698	2.700
7.3	2.702	2.704	2.706	2.707	2.709	2.711	2.713	2.715	2.717	2.718
7.4	2.720	2.722	2.724	2.726	2.728	2.729	2.731	2.733	2.735	2.737
7.5	2.739	2.740	2.742	2.744	2.746	2.748	2.750	2.751	2.753	2.755
7.6	2.757	2.759	2.760	2.762	2.764	2.766	2.768	2.769	2.771	2.773
7.7	2.775	2.777	2.778	2.780	2.782	2.784	2.786	2.787	2.789	2.791
7.8	2.793	2.795	2.796	2.798	2.800	2.802	2.804	2.805	2.807	2.809
7.9	2.811	2.812	2.814	2.816	2.818	2.820	2.821	2.823	2.825	2.827
8.0	2.828	2.830	2.832	2.834	2.835	2.837	2.839	2.841	2.843	2.844
8.1	2.846	2.848	2.850	2.851	2.853	2.855	2.857	2.858	2.860	2.862
8.2	2.864	2.865	2.867	2.869	2.871	2.872	2.874	2.876	2.877	2.879
8.3	2.881	2.883	2.884	2.886	2.888	2.890	2.891	2.893	2.895	2.897
8.4	2.898	2.900	2.902	2.903	2.905	2.907	2.909	2.910	2.912	2.914
8.5	2.915	2.917	2.919	2.921	2.922	2.924	2.926	2.927	2.929	2.931
8.6	2.933	2.934	2.936	2.938	2.939	2.941	2.943	2.944	2.946	2.948
8.7	2.950	2.951	2.953	2.955	2.956	2.958	2.960	2.961	2.963	2.965
8.8	2.966	2.968	2.970	2.972	2.973	2.975	2.977	2.978	2.980	2.982
8.9	2.983	2.985	2.987	2.988	2.990	2.992	2.993	2.995	2.997	2.998
9.0	3.000	3.002	3.003	3.005	3.007	3.008	3.010	3.012	3.013	3.015
9.1	3.017	3.018	3.020	3.022	3.023	3.025	3.027	3.028	3.030	3.032
9.2	3.033	3.035	3.036	3.038	3.040	3.041	3.043	3.045	3.046	3.048
9.3	3.050	3.051	3.053	3.055	3.056	3.058	3.059	3.061	3.063	3.064
9.4	3.066	3.068	3.069	3.071	3.072	3.074	3.076	3.077	3.079	3.081
9.5	3.082	3.084	3.085	3.087	3.089	3.090	3.092	3.094	3.095	3.097
9.6	3.098	3.100	3.102	3.103	3.105	3.106	3.108	3.110	3.111	3.113
9.7	3.114	3.116	3.118	3.119	3.121	3.122	3.124	3.126	3.127	3.129
9.8	3.130	3.132	3.134	3.135	3.137	3.138	3.140	3.142	3.143	3.145
9.9	3.146	3.148	3.150	3.151	3.153	3.154	3.156	3.158	3.159	3.161
<i>n</i>	0	1	2	3	4	5	6	7	8	9

Continued from p. 17

<i>n</i>	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
10	3.162	3.178	3.194	3.209	3.225	3.240	3.256	3.271	3.286	3.302
11	3.317	3.332	3.347	3.362	3.376	3.391	3.406	3.421	3.435	3.450
12	3.464	3.479	3.493	3.507	3.521	3.536	3.550	3.564	3.578	3.592
13	3.606	3.619	3.633	3.647	3.661	3.674	3.688	3.701	3.715	3.728
14	3.742	3.755	3.768	3.782	3.795	3.808	3.821	3.834	3.847	3.860
15	3.873	3.886	3.899	3.912	3.924	3.937	3.950	3.962	3.975	3.987
16	4.000	4.012	4.025	4.037	4.050	4.062	4.074	4.087	4.099	4.111
17	4.123	4.135	4.147	4.159	4.171	4.183	4.195	4.207	4.219	4.231
18	4.243	4.254	4.266	4.278	4.290	4.301	4.313	4.324	4.336	4.347
19	4.359	4.370	4.382	4.393	4.405	4.416	4.427	4.438	4.450	4.461
20	4.472	4.483	4.494	4.506	4.517	4.528	4.539	4.550	4.561	4.572
21	4.583	4.593	4.604	4.615	4.626	4.637	4.648	4.658	4.669	4.680
22	4.690	4.701	4.712	4.722	4.733	4.743	4.754	4.764	4.775	4.785
23	4.796	4.806	4.817	4.827	4.837	4.848	4.858	4.868	4.879	4.889
24	4.899	4.909	4.919	4.930	4.940	4.950	4.960	4.970	4.980	4.990
25	5.000	5.010	5.020	5.030	5.040	5.050	5.060	5.070	5.079	5.089
26	5.099	5.109	5.119	5.128	5.138	5.148	5.158	5.167	5.177	5.187
27	5.196	5.206	5.215	5.225	5.235	5.244	5.254	5.263	5.273	5.282
28	5.292	5.301	5.310	5.320	5.329	5.339	5.348	5.357	5.367	5.376
29	5.385	5.394	5.404	5.413	5.422	5.431	5.441	5.450	5.459	5.468
30	5.477	5.486	5.495	5.505	5.514	5.523	5.532	5.541	5.550	5.559
31	5.568	5.577	5.586	5.595	5.604	5.612	5.621	5.630	5.639	5.648
32	5.657	5.666	5.675	5.683	5.692	5.701	5.710	5.718	5.727	5.736
33	5.745	5.753	5.762	5.771	5.779	5.788	5.797	5.805	5.814	5.822
34	5.831	5.840	5.848	5.857	5.865	5.874	5.882	5.891	5.899	5.908
35	5.916	5.925	5.933	5.941	5.950	5.958	5.967	5.975	5.983	5.992
36	6.000	6.008	6.017	6.025	6.033	6.042	6.050	6.058	6.066	6.075
37	6.083	6.091	6.099	6.107	6.116	6.124	6.132	6.140	6.148	6.156
38	6.164	6.173	6.181	6.189	6.197	6.205	6.213	6.221	6.229	6.237
39	6.245	6.253	6.261	6.269	6.277	6.285	6.293	6.301	6.309	6.317
40	6.325	6.332	6.340	6.348	6.356	6.364	6.372	6.380	6.387	6.395
41	6.403	6.411	6.419	6.427	6.434	6.442	6.450	6.458	6.465	6.473
42	6.481	6.488	6.496	6.504	6.512	6.519	6.527	6.535	6.542	6.550
43	6.557	6.565	6.573	6.580	6.588	6.595	6.603	6.611	6.618	6.626
44	6.633	6.641	6.648	6.656	6.663	6.671	6.678	6.686	6.693	6.701
45	6.708	6.716	6.723	6.731	6.738	6.745	6.753	6.760	6.768	6.775
46	6.782	6.790	6.797	6.804	6.812	6.819	6.826	6.834	6.841	6.848
47	6.856	6.863	6.870	6.877	6.885	6.892	6.899	6.907	6.914	6.921
48	6.928	6.935	6.943	6.950	6.957	6.964	6.971	6.979	6.986	6.993
49	7.000	7.007	7.014	7.021	7.029	7.036	7.043	7.050	7.057	7.064
50	7.071	7.078	7.085	7.092	7.099	7.106	7.113	7.120	7.127	7.134
51	7.141	7.148	7.155	7.162	7.169	7.176	7.183	7.190	7.197	7.204
52	7.211	7.218	7.225	7.232	7.239	7.246	7.253	7.259	7.266	7.273
53	7.280	7.287	7.294	7.301	7.308	7.314	7.321	7.328	7.335	7.342
54	7.348	7.355	7.362	7.369	7.376	7.382	7.389	7.396	7.403	7.409
<i>n</i>	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9

Numbers from 1.00 to 99.9

<i>n</i>	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
55	7.416	7.423	7.430	7.436	7.443	7.450	7.457	7.463	7.470	7.477
56	7.483	7.490	7.497	7.503	7.510	7.517	7.523	7.530	7.537	7.543
57	7.550	7.556	7.563	7.570	7.576	7.583	7.589	7.596	7.603	7.609
58	7.616	7.622	7.629	7.635	7.642	7.649	7.655	7.662	7.668	7.675
59	7.681	7.688	7.694	7.701	7.707	7.714	7.720	7.727	7.733	7.740
60	7.746	7.752	7.759	7.765	7.772	7.778	7.785	7.791	7.797	7.804
61	7.810	7.817	7.823	7.829	7.836	7.842	7.849	7.855	7.861	7.868
62	7.874	7.880	7.887	7.893	7.899	7.906	7.912	7.918	7.925	7.931
63	7.937	7.944	7.950	7.956	7.962	7.969	7.975	7.981	7.987	7.994
64	8.000	8.006	8.012	8.019	8.025	8.031	8.037	8.044	8.050	8.056
65	8.062	8.068	8.075	8.081	8.087	8.093	8.099	8.106	8.112	8.118
66	8.124	8.130	8.136	8.142	8.149	8.155	8.161	8.167	8.173	8.179
67	8.185	8.191	8.198	8.204	8.210	8.216	8.222	8.228	8.234	8.240
68	8.246	8.252	8.258	8.264	8.270	8.276	8.283	8.289	8.295	8.301
69	8.307	8.313	8.319	8.325	8.331	8.337	8.343	8.349	8.355	8.361
70	8.367	8.373	8.379	8.385	8.390	8.396	8.402	8.408	8.414	8.420
71	8.426	8.432	8.438	8.444	8.450	8.456	8.462	8.468	8.473	8.479
72	8.485	8.491	8.497	8.503	8.509	8.515	8.521	8.526	8.532	8.538
73	8.544	8.550	8.556	8.562	8.567	8.573	8.579	8.585	8.591	8.597
74	8.602	8.608	8.614	8.620	8.626	8.631	8.637	8.643	8.649	8.654
75	8.660	8.666	8.672	8.678	8.683	8.689	8.695	8.701	8.706	8.712
76	8.718	8.724	8.729	8.735	8.741	8.746	8.752	8.758	8.764	8.769
77	8.775	8.781	8.786	8.792	8.798	8.803	8.809	8.815	8.820	8.826
78	8.832	8.837	8.843	8.849	8.854	8.860	8.866	8.871	8.877	8.883
79	8.888	8.894	8.899	8.905	8.911	8.916	8.922	8.927	8.933	8.939
80	8.944	8.950	8.955	8.961	8.967	8.972	8.978	8.983	8.989	8.994
81	9.000	9.006	9.011	9.017	9.022	9.028	9.033	9.039	9.044	9.050
82	9.055	9.061	9.066	9.072	9.077	9.083	9.088	9.094	9.099	9.105
83	9.110	9.116	9.121	9.127	9.132	9.138	9.143	9.149	9.154	9.160
84	9.165	9.171	9.176	9.182	9.187	9.192	9.198	9.203	9.209	9.214
85	9.220	9.225	9.230	9.236	9.241	9.247	9.252	9.257	9.263	9.268
86	9.274	9.279	9.284	9.290	9.295	9.301	9.306	9.311	9.317	9.322
87	9.327	9.333	9.338	9.343	9.349	9.354	9.359	9.365	9.370	9.375
88	9.381	9.386	9.391	9.397	9.402	9.407	9.413	9.418	9.423	9.429
89	9.434	9.439	9.445	9.450	9.455	9.460	9.466	9.471	9.476	9.482
90	9.487	9.492	9.497	9.503	9.508	9.513	9.518	9.524	9.529	9.534
91	9.539	9.545	9.550	9.555	9.560	9.566	9.571	9.576	9.581	9.586
92	9.592	9.597	9.602	9.607	9.612	9.618	9.623	9.628	9.633	9.638
93	9.644	9.649	9.654	9.659	9.664	9.670	9.675	9.680	9.685	9.690
94	9.695	9.701	9.706	9.711	9.716	9.721	9.726	9.731	9.737	9.742
95	9.747	9.752	9.757	9.762	9.767	9.772	9.778	9.783	9.788	9.793
96	9.798	9.803	9.808	9.813	9.818	9.823	9.829	9.834	9.839	9.844
97	9.849	9.854	9.859	9.864	9.869	9.874	9.879	9.884	9.889	9.894
98	9.899	9.905	9.910	9.915	9.920	9.925	9.930	9.935	9.940	9.945
99	9.950	9.955	9.960	9.965	9.970	9.975	9.980	9.985	9.990	9.995
<i>n</i>	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9

9. Cues of Num-

n	0	1	2	3	4	5	6	7	8	9
1.0	1.000	1.030	1.061	1.093	1.125	1.158	1.191	1.225	1.260	1.295
1.1	1.331	1.368	1.405	1.443	1.482	1.521	1.561	1.602	1.643	1.685
1.2	1.728	1.772	1.816	1.861	1.907	1.953	2.000	2.048	2.097	2.147
1.3	2.197	2.248	2.300	2.353	2.406	2.460	2.515	2.571	2.628	2.686
1.4	2.744	2.803	2.863	2.924	2.986	3.049	3.112	3.177	3.242	3.308
1.5	3.375	3.443	3.512	3.582	3.652	3.724	3.796	3.870	3.944	4.020
1.6	4.096	4.173	4.252	4.331	4.411	4.492	4.574	4.657	4.742	4.827
1.7	4.913	5.000	5.088	5.178	5.268	5.359	5.452	5.545	5.640	5.735
1.8	5.832	5.930	6.029	6.128	6.230	6.332	6.435	6.539	6.645	6.751
1.9	6.859	6.968	7.078	7.189	7.301	7.415	7.530	7.645	7.762	7.881
2.0	8.000	8.121	8.242	8.365	8.490	8.615	8.742	8.870	8.999	9.129
2.1	9.261	9.394	9.528	9.664	9.800	9.938	10.08	10.22	10.36	10.50
2.2	10.65	10.79	10.94	11.09	11.24	11.39	11.54	11.70	11.85	12.01
2.3	12.17	12.33	12.49	12.65	12.81	12.98	13.14	13.31	13.48	13.65
2.4	13.82	14.00	14.17	14.35	14.53	14.71	14.89	15.07	15.25	15.44
2.5	15.62	15.81	16.00	16.19	16.39	16.58	16.78	16.97	17.17	17.37
2.6	17.58	17.78	17.98	18.19	18.40	18.61	18.82	19.03	19.25	19.47
2.7	19.68	19.90	20.12	20.35	20.57	20.80	21.02	21.25	21.48	21.72
2.8	21.95	22.19	22.43	22.67	22.91	23.15	23.39	23.64	23.89	24.14
2.9	24.39	24.64	24.90	25.15	25.41	25.67	25.93	26.20	26.46	26.73
3.0	27.00	27.27	27.54	27.82	28.09	28.37	28.65	28.93	29.22	29.50
3.1	29.79	30.08	30.37	30.66	30.96	31.26	31.55	31.86	32.16	32.46
3.2	32.77	33.08	33.39	33.70	34.01	34.33	34.65	34.97	35.29	35.61
3.3	35.94	36.26	36.59	36.93	37.26	37.60	37.93	38.27	38.61	38.96
3.4	39.30	39.65	40.00	40.35	40.71	41.06	41.42	41.78	42.14	42.51
3.5	42.88	43.24	43.61	43.99	44.36	44.74	45.12	45.50	45.88	46.27
3.6	46.66	47.05	47.44	47.83	48.23	48.63	49.03	49.43	49.84	50.24
3.7	50.65	51.06	51.48	51.90	52.31	52.73	53.16	53.58	54.01	54.44
3.8	54.87	55.31	55.74	56.18	56.62	57.07	57.51	57.96	58.41	58.86
3.9	59.32	59.78	60.24	60.70	61.16	61.63	62.10	62.57	63.04	63.52
4.0	64.00	64.48	64.96	65.45	65.94	66.43	66.92	67.42	67.92	68.42
4.1	68.92	69.43	69.93	70.44	70.96	71.47	71.99	72.51	73.03	73.56
4.2	74.09	74.62	75.15	75.69	76.23	76.77	77.31	77.85	78.40	78.95
4.3	79.51	80.06	80.62	81.18	81.75	82.31	82.88	83.45	84.03	84.60
4.4	85.18	85.77	86.35	86.94	87.53	88.12	88.72	89.31	89.92	90.52
4.5	91.12	91.73	92.35	92.96	93.58	94.20	94.82	95.44	96.07	96.70
4.6	97.34	97.97	98.61	99.25	99.90	100.5	101.2	101.8	102.5	103.2
4.7	103.8	104.5	105.2	105.8	106.5	107.2	107.9	108.5	109.2	109.9
4.8	110.6	111.3	112.0	112.7	113.4	114.1	114.8	115.5	116.2	116.9
4.9	117.6	118.4	119.1	119.8	120.6	121.3	122.0	122.8	123.5	124.3
5.0	125.0	125.8	126.5	127.3	128.0	128.8	129.6	130.3	131.1	131.9
5.1	132.7	133.4	134.2	135.0	135.8	136.6	137.4	138.2	139.0	139.8
5.2	140.6	141.4	142.2	143.1	143.9	144.7	145.5	146.4	147.2	148.0
5.3	148.9	149.7	150.6	151.4	152.3	153.1	154.0	154.9	155.7	156.6
5.4	157.5	158.3	159.2	160.1	161.0	161.9	162.8	163.7	164.6	165.5
n	0	1	2	3	4	5	6	7	8	9

bers from 1.00 to 9.99

<i>n</i>	0	1	2	3	4	5	6	7	8	9
5.5	166.4	167.3	168.2	169.1	170.0	171.0	171.9	172.8	173.7	174.7
5.6	175.6	176.6	177.5	178.5	179.4	180.4	181.3	182.3	183.3	184.2
5.7	185.2	186.2	187.1	188.1	189.1	190.1	191.1	192.1	193.1	194.1
5.8	195.1	196.1	197.1	198.2	199.2	200.2	201.2	202.3	203.3	204.3
5.9	205.4	206.4	207.5	208.5	209.6	210.6	211.7	212.8	213.8	214.9
6.0	216.0	217.1	218.2	219.3	220.3	221.4	222.5	223.6	224.8	225.9
6.1	227.0	228.1	229.2	230.3	231.5	232.6	233.7	234.9	236.0	237.2
6.2	238.3	239.5	240.6	241.8	243.0	244.1	245.3	246.5	247.7	248.9
6.3	250.0	251.2	252.4	253.6	254.8	256.0	257.3	258.5	259.7	260.9
6.4	262.1	263.4	264.6	265.8	267.1	268.3	269.6	270.8	272.1	273.4
6.5	274.6	275.9	277.2	278.4	279.7	281.0	282.3	283.6	284.9	286.2
6.6	287.5	288.8	290.1	291.4	292.8	294.1	295.4	296.7	298.1	299.4
6.7	300.8	302.1	303.5	304.8	306.2	307.5	308.9	310.3	311.7	313.0
6.8	314.4	315.8	317.2	318.6	320.0	321.4	322.8	324.2	325.7	327.1
6.9	328.5	329.9	331.4	332.8	334.3	335.7	337.2	338.6	340.1	341.5
7.0	343.0	344.5	345.9	347.4	348.9	350.4	351.9	353.4	354.9	356.4
7.1	357.9	359.4	360.9	362.5	364.0	365.5	367.1	368.6	370.1	371.7
7.2	373.2	374.8	376.4	377.9	379.5	381.1	382.7	384.2	385.8	387.4
7.3	389.0	390.6	392.2	393.8	395.4	397.1	398.7	400.3	401.9	403.6
7.4	405.2	406.9	408.5	410.2	411.8	413.5	415.2	416.8	418.5	420.2
7.5	421.9	423.6	425.3	427.0	428.7	430.4	432.1	433.8	435.5	437.2
7.6	439.0	440.7	442.5	444.2	445.9	447.7	449.5	451.2	453.0	454.8
7.7	456.5	458.3	460.1	461.9	463.7	465.5	467.3	469.1	470.9	472.7
7.8	474.6	476.4	478.2	480.0	481.9	483.7	485.6	487.4	489.3	491.2
7.9	493.0	494.9	496.8	498.7	500.6	502.5	504.4	506.3	508.2	510.1
8.0	512.0	513.9	515.8	517.8	519.7	521.7	523.6	525.6	527.5	529.5
8.1	531.4	533.4	535.4	537.4	539.4	541.3	543.3	545.3	547.3	549.4
8.2	551.4	553.4	555.4	557.4	559.5	561.5	563.6	565.6	567.7	569.7
8.3	571.8	573.9	575.9	578.0	580.1	582.2	584.3	586.4	588.5	590.6
8.4	592.7	594.8	596.9	599.1	601.2	603.4	605.5	607.6	609.8	612.0
8.5	614.1	616.3	618.5	620.7	622.8	625.0	627.2	629.4	631.6	633.8
8.6	636.1	638.3	640.5	642.7	645.0	647.2	649.5	651.7	654.0	656.2
8.7	658.5	660.8	663.1	665.3	667.6	669.9	672.2	674.5	676.8	679.2
8.8	681.5	683.8	686.1	688.5	690.8	693.2	695.5	697.9	700.2	702.6
8.9	705.0	707.3	709.7	712.1	714.5	716.9	719.3	721.7	724.2	726.6
9.0	729.0	731.4	733.9	736.3	738.8	741.2	743.7	746.1	748.6	751.1
9.1	753.6	756.1	758.6	761.0	763.6	766.1	768.6	771.1	773.6	776.2
9.2	778.7	781.2	783.8	786.3	788.9	791.5	794.0	796.6	799.2	801.8
9.3	804.4	807.0	809.6	812.2	814.8	817.4	820.0	822.7	825.3	827.9
9.4	830.6	833.2	835.9	838.6	841.2	843.9	846.6	849.3	852.0	854.7
9.5	857.4	860.1	862.8	865.5	868.3	871.0	873.7	876.5	879.2	882.0
9.6	884.7	887.5	890.3	893.1	895.8	898.6	901.4	904.2	907.0	909.9
9.7	912.7	915.5	918.3	921.2	924.0	926.9	929.7	932.6	935.4	938.3
9.8	941.2	944.1	947.0	949.9	952.8	955.7	958.6	961.5	964.4	967.4
9.9	970.3	973.2	976.2	979.1	982.1	985.1	988.0	991.0	994.0	997.0
<i>n</i>	0	1	2	3	4	5	6	7	8	9

10. Cube Roots of Numbers

n	$\sqrt[3]{n}$	$\sqrt[3]{10n}$	$\sqrt[3]{100n}$	n	$\sqrt[3]{n}$	$\sqrt[3]{10n}$	$\sqrt[3]{100n}$
10	2.1544	4.6416	10.000	55	3.8030	8.1932	17.652
11	2.2240	4.7914	10.323	56	3.8259	8.2426	17.758
12	2.2894	4.9324	10.627	57	3.8485	8.2913	17.863
13	2.3513	5.0658	10.914	58	3.8709	8.3396	17.967
14	2.4101	5.1925	11.187	59	3.8930	8.3872	18.070
15	2.4662	5.3133	11.447	60	3.9149	8.4343	18.171
16	2.5198	5.4288	11.696	61	3.9365	8.4809	18.272
17	2.5713	5.5397	11.935	62	3.9579	8.5270	18.371
18	2.6207	5.6462	12.164	63	3.9791	8.5726	18.469
19	2.6684	5.7489	12.386	64	4.0000	8.6177	18.566
20	2.7144	5.8480	12.599	65	4.0207	8.6624	18.663
21	2.7589	5.9439	12.806	66	4.0412	8.7066	18.758
22	2.8020	6.0368	13.006	67	4.0615	8.7503	18.852
23	2.8439	6.1269	13.200	68	4.0817	8.7937	18.945
24	2.8845	6.2145	13.389	69	4.1016	8.8366	19.038
25	2.9240	6.2996	13.572	70	4.1213	8.8790	19.129
26	2.9625	6.3825	13.751	71	4.1408	8.9211	19.220
27	3.0000	6.4633	13.925	72	4.1602	8.9628	19.310
28	3.0366	6.5421	14.095	73	4.1793	9.0041	19.399
29	3.0723	6.6191	14.260	74	4.1983	9.0450	19.487
30	3.1072	6.6943	14.422	75	4.2172	9.0856	19.574
31	3.1414	6.7679	14.581	76	4.2358	9.1258	19.661
32	3.1748	6.8399	14.736	77	4.2543	9.1657	19.747
33	3.2075	6.9104	14.888	78	4.2727	9.2052	19.832
34	3.2396	6.9795	15.037	79	4.2908	9.2443	19.916
35	3.2711	7.0473	15.183	80	4.3089	9.2832	20.000
36	3.3019	7.1138	15.326	81	4.3267	9.3217	20.083
37	3.3322	7.1791	15.467	82	4.3445	9.3599	20.165
38	3.3620	7.2432	15.605	83	4.3621	9.3978	20.247
39	3.3912	7.3061	15.741	84	4.3795	9.4354	20.328
40	3.4200	7.3681	15.874	85	4.3968	9.4727	20.408
41	3.4482	7.4290	16.005	86	4.4140	9.5097	20.488
42	3.4760	7.4889	16.134	87	4.4310	9.5464	20.567
43	3.5034	7.5478	16.261	88	4.4480	9.5828	20.646
44	3.5303	7.6059	16.386	89	4.4647	9.6190	20.724
45	3.5569	7.6631	16.510	90	4.4814	9.6549	20.801
46	3.5830	7.7194	16.631	91	4.4979	9.6905	20.878
47	3.6088	7.7750	16.751	92	4.5144	9.7259	20.954
48	3.6342	7.8297	16.869	93	4.5307	9.7610	21.029
49	3.6593	7.8837	16.985	94	4.5468	9.7959	21.105
50	3.6840	7.9370	17.100	95	4.5629	9.8305	21.179
51	3.7084	7.9896	17.213	96	4.5789	9.8648	21.253
52	3.7325	8.0415	17.325	97	4.5947	9.8990	21.327
53	3.7563	8.0927	17.435	98	4.6104	9.9329	21.400
54	3.7798	8.1433	17.544	99	4.6261	9.9666	21.472

11. Three-Halves Powers of Numbers

<i>n</i>	0	1	2	3	4	5	6	7	8	9
0.0	0.000	0.001	0.003	0.005	0.008	0.011	0.015	0.019	0.023	0.027
0.1	0.032	0.036	0.042	0.047	0.052	0.058	0.064	0.070	0.076	0.083
0.2	0.089	0.096	0.103	0.110	0.118	0.125	0.133	0.140	0.148	0.156
0.3	0.164	0.173	0.181	0.190	0.198	0.207	0.216	0.225	0.234	0.244
0.4	0.253	0.263	0.272	0.282	0.292	0.302	0.312	0.322	0.333	0.343
0.5	0.354	0.364	0.375	0.386	0.397	0.408	0.419	0.430	0.442	0.453
0.6	0.465	0.476	0.488	0.500	0.512	0.524	0.536	0.548	0.561	0.573
0.7	0.586	0.598	0.611	0.624	0.637	0.650	0.663	0.676	0.689	0.702
0.8	0.716	0.729	0.743	0.756	0.770	0.784	0.798	0.811	0.826	0.840
0.9	0.854	0.868	0.882	0.897	0.911	0.926	0.941	0.955	0.970	0.985
1.0	1.000	1.015	1.030	1.045	1.061	1.076	1.091	1.107	1.122	1.138
1.1	1.154	1.170	1.185	1.201	1.217	1.233	1.249	1.266	1.282	1.298
1.2	1.315	1.331	1.348	1.364	1.381	1.398	1.414	1.431	1.448	1.465
1.3	1.482	1.499	1.517	1.534	1.551	1.569	1.586	1.604	1.621	1.639
1.4	1.657	1.674	1.692	1.710	1.728	1.746	1.764	1.782	1.800	1.819
1.5	1.837	1.856	1.874	1.893	1.911	1.930	1.948	1.967	1.986	2.005
1.6	2.024	2.043	2.062	2.081	2.100	2.119	2.139	2.158	2.178	2.197
1.7	2.217	2.236	2.256	2.275	2.295	2.315	2.335	2.355	2.375	2.395
1.8	2.415	2.435	2.455	2.476	2.496	2.516	2.537	2.557	2.578	2.598
1.9	2.619	2.640	2.660	2.681	2.702	2.723	2.744	2.765	2.786	2.807
2.0	2.828	2.850	2.871	2.892	2.914	2.935	2.957	2.978	3.000	3.021
2.1	3.043	3.065	3.087	3.109	3.131	3.153	3.175	3.197	3.219	3.241
2.2	3.263	3.285	3.308	3.330	3.353	3.375	3.398	3.420	3.443	3.465
2.3	3.488	3.511	3.534	3.557	3.580	3.602	3.626	3.649	3.672	3.695
2.4	3.718	3.741	3.765	3.788	3.811	3.835	3.858	3.882	3.906	3.929
2.5	3.953	3.977	4.000	4.024	4.048	4.072	4.096	4.120	4.144	4.168
2.6	4.192	4.217	4.241	4.265	4.289	4.314	4.338	4.363	4.387	4.412
2.7	4.437	4.461	4.486	4.511	4.536	4.560	4.585	4.610	4.635	4.660
2.8	4.685	4.710	4.736	4.761	4.786	4.811	4.837	4.862	4.888	4.913
2.9	4.939	4.964	4.990	5.015	5.041	5.067	5.093	5.118	5.144	5.170
3.0	5.196	5.222	5.248	5.274	5.300	5.327	5.353	5.379	5.405	5.432
3.1	5.458	5.485	5.511	5.538	5.564	5.591	5.617	5.644	5.671	5.698
3.2	5.724	5.751	5.778	5.805	5.832	5.859	5.886	5.913	5.940	5.968
3.3	5.995	6.022	6.049	6.077	6.104	6.132	6.159	6.186	6.214	6.242
3.4	6.269	6.297	6.325	6.352	6.380	6.408	6.436	6.464	6.492	6.520
3.5	6.548	6.576	6.604	6.632	6.660	6.689	6.717	6.745	6.774	6.802
3.6	6.831	6.859	6.888	6.916	6.945	6.973	7.002	7.031	7.059	7.088
3.7	7.117	7.146	7.175	7.204	7.233	7.262	7.291	7.320	7.349	7.378
3.8	7.408	7.437	7.466	7.495	7.525	7.554	7.584	7.613	7.643	7.672
3.9	7.702	7.732	7.761	7.791	7.821	7.850	7.880	7.910	7.940	7.970
4.0	8.000	8.030	8.060	8.090	8.120	8.150	8.181	8.211	8.241	8.272
4.1	8.302	8.332	8.363	8.393	8.424	8.454	8.485	8.515	8.546	8.577
4.2	8.607	8.638	8.669	8.700	8.731	8.762	8.793	8.824	8.855	8.886
4.3	8.917	8.948	8.979	9.010	9.041	9.073	9.104	9.135	9.167	9.198
4.4	9.230	9.261	9.293	9.324	9.356	9.387	9.419	9.451	9.482	9.514
<i>n</i>	0	1	2	3	4	5	6	7	8	9

12. Fifth Powers and Roots; Five-Halves Powers and Roots

n	n^5	$n^{\frac{1}{5}}$	$n^{\frac{2}{5}}$	$n^{\frac{3}{5}}$	n	n^5	$n^{\frac{1}{5}}$	$n^{\frac{2}{5}}$	$n^{\frac{3}{5}}$
0.1	0.0000	0.6310	0.0032	0.3981	4.6	2059.6	1.3569	45.383	1.8412
0.2	0.0003	0.7248	0.0179	0.5253	4.7	2293.5	1.3628	47.890	1.8571
0.3	0.0024	0.7860	0.0493	0.6178	4.8	2548.0	1.3685	50.478	1.8728
0.4	0.0102	0.8326	0.1012	0.6931	4.9	2824.8	1.3742	53.148	1.8883
0.5	0.0312	0.8706	0.1768	0.7579	5.0	3125.0	1.3797	55.902	1.9037
0.6	0.0778	0.9029	0.2789	0.8152	5.1	3450.3	1.3852	58.739	1.9188
0.7	0.1681	0.9311	0.4100	0.8670	5.2	3802.0	1.3906	61.661	1.9338
0.8	0.3277	0.9564	0.5724	0.9146	5.3	4182.0	1.3959	64.668	1.9485
0.9	0.5905	0.9791	0.7684	0.9587	5.4	4591.7	1.4011	67.762	1.9632
1.0	1.0000	1.0000	1.0000	1.0000	5.5	5032.8	1.4063	70.943	1.9776
1.1	1.6105	1.0192	1.2691	1.0389	5.6	5507.3	1.4114	74.211	1.9919
1.2	2.4883	1.0371	1.5774	1.0757	5.7	6016.9	1.4164	77.569	2.0061
1.3	3.7129	1.0539	1.9269	1.1107	5.8	6563.6	1.4213	81.016	2.0201
1.4	5.3782	1.0696	2.3191	1.1441	5.9	7149.2	1.4262	84.553	2.0340
1.5	7.5938	1.0845	2.7557	1.1761	6.0	7776.0	1.4310	88.182	2.0477
1.6	10.486	1.0986	3.2382	1.2068	6.1	8446.0	1.4357	91.902	2.0613
1.7	14.199	1.1120	3.7681	1.2365	6.2	9161.3	1.4404	95.715	2.0747
1.8	18.896	1.1247	4.3469	1.2651	6.3	9924.4	1.4450	99.621	2.0880
1.9	24.761	1.1370	4.9760	1.2927	6.4	10737.	1.4496	103.62	2.1012
2.0	32.000	1.1487	5.6569	1.3195	6.5	11603.	1.4541	107.7?	2.1143
2.1	40.841	1.1600	6.3907	1.3455	6.6	12523.	1.4585	111.91	2.1272
2.2	51.536	1.1708	7.1789	1.3708	6.7	13501.	1.4629	116.19	2.1401
2.3	64.363	1.1813	8.0227	1.3954	6.8	14539.	1.4672	120.58	2.1528
2.4	79.626	1.1914	8.9234	1.4193	6.9	15640.	1.4715	125.06	2.1654
2.5	97.656	1.2011	9.8821	1.4427	7.0	16807.	1.4758	129.64	2.1779
2.6	118.81	1.2106	10.900	1.4655	7.1	18042.	1.4800	134.32	2.1903
2.7	143.49	1.2198	11.979	1.4878	7.2	19349.	1.4841	139.10	2.2026
2.8	172.10	1.2287	13.119	1.5096	7.3	20731.	1.4882	143.98	2.2148
2.9	205.11	1.2373	14.322	1.5309	7.4	22190.	1.4923	148.96	2.2269
3.0	243.00	1.2457	15.588	1.5518	7.5	23730.	1.4963	154.05	2.2388
3.1	286.29	1.2539	16.920	1.5723	7.6	25355.	1.5002	159.23	2.2507
3.2	335.54	1.2619	18.318	1.5924	7.7	27068.	1.5042	164.52	2.2625
3.3	391.35	1.2697	19.783	1.6122	7.8	28872.	1.5081	169.92	2.2742
3.4	454.35	1.2773	21.316	1.6315	7.9	30771.	1.5119	175.42	2.2859
3.5	525.22	1.2847	22.918	1.6505	8.0	32768.	1.5157	181.02	2.2974
3.6	604.66	1.2920	24.590	1.6692	8.2	37074.	1.5232	192.55	2.3202
3.7	693.44	1.2991	26.333	1.6876	8.4	41821.	1.5306	204.50	2.3427
3.8	792.35	1.3060	28.149	1.7057	8.6	47043.	1.5378	216.89	2.3648
3.9	902.24	1.3128	30.037	1.7236	8.8	52773.	1.5449	229.72	2.3867
4.0	1024.0	1.3195	32.000	1.7411	9.0	59049.	1.5518	243.00	2.4082
4.1	1158.6	1.3260	34.038	1.7584	9.2	65908.	1.5587	256.73	2.4295
4.2	1306.9	1.3324	36.151	1.7754	9.4	73390.	1.5654	270.91	2.4505
4.3	1470.1	1.3387	38.342	1.7922	9.6	81537.	1.5720	285.55	2.4712
4.4	1649.2	1.3449	40.610	1.8088	9.8	90392.	1.5785	300.65	2.4917
4.5	1845.3	1.3510	42.957	1.8251	10	100000	1.5849	316.23	2.5119

13. Explanations

All of the Arithmetical Tables, except 10 and 12, are four-place tables, that is, the values of the functions are given to four significant figures. In Tables 10 and 12 five significant figures are given. For all these tables the probable error in the last figure is one-fourth of a unit.

Table 6 gives Reciprocals of all numbers having three significant figures by properly moving the decimal point. Thus the reciprocals of 0.705, 7.05, 705, and 0.0705 are 1.418, 0.1418, 0.001418, and 14.18 to four significant figures.

Table 7 gives Squares of all numbers having three significant figures by properly moving the decimal point. Thus the squares of 3.94, 0.394, and 39.4 are 15.52, 0.1552, and 1552 to four significant figures. Here the decimal point moves two places in the function when it moves one place in the argument.

Table 8 gives Square Roots of all numbers of three significant figures. For the numbers 5.42 and 542 the square roots 2.328 and 23.28 are found on page 16; for the numbers 54.2 and 5420 the square roots 7.362 and 73.62 are found on page 18. Here, as in Table 7, the decimal point moves two places in the square when it moves one place in the square root.

Table 9 gives Cubes of all numbers of three significant figures by moving the decimal point three places in the function when it moves one place in the argument. Thus, the cubes of 4.69 and 0.469 are 103.2 and 0.1032 to four significant figures.

Table 10 gives Cube Roots of two-place numbers. Thus, the cube root of 35 is 3.2711, that of 350 is 7.0473, and that of 3500 is 15.183. When the given number contains a decimal point, multiply it by 1000, take the root from the table and then divide this by 10. In this manner the cube roots of 3.5, 0.35, and 0.0035 are found to be 1.5183, 0.7047, and 0.3271.

Table 11 gives values of $n^{\frac{3}{2}}$ or $\sqrt{n^3}$ for values of n up to 4.49. This is useful in the weir computations of hydraulics. For example, when n is 2.59 the value of $n^{\frac{3}{2}}$ is 5.432. Table 12 is also used in hydraulic work in computations on the flow of water in long pipes.

14. Exercises for Students

1. Find the reciprocals of 0.14, 0.145, and 0.1456; also of 1.4, 1.45, and 1.456; also of 14, 14.5, and 14.56.

2. Find the reciprocals of 0.90, 0.99, and 0.909; also of 0.695, 0.6954, and 6.954; also of 0.295, 0.2954, 29.5, and 295.4.

3. Find the squares of 3.90, 3.902, and 3.909; also of 39.0, 39.02, and 39.09; also of 0.77, 0.777, and 0.7777; also of 0.707 and 0.7071.

4. Find the square roots of the following numbers:

2.08	2.081	2.087
2.09	2.091	2.097
9.43	9.433	9.435
20.8	20.81	20.87
20.9	20.91	20.97
94.3	94.33	94.35
0.89	0.891	0.8913
89.0	89.1	89.13
8900	8910	8913

5. Find the value of $\sqrt{3^2+4^2+12^2}$ by the help of Tables 7 and 8.

6. Find the values of the following functions:

$4.23^2 =$	$4.231^2 =$	$42.31^2 =$
$8.95^2 =$	$89.5^2 =$	$895^2 =$
$0.723^2 =$	$0.0723^2 =$	$723^2 =$
$7.25^3 =$	$72.5^3 =$	$725^3 =$
$7.04^3 =$	$0.704^3 =$	$704^3 =$
$0.999^3 =$	$9.99^3 =$	$99.9^3 =$

7. Find the value of $\sqrt[3]{3^3+4^3+5^3}$ by the help of Table 8.

8. Find the three-halves powers of 2.78 and 2.783.

9. Find the values of the following functions:

$1/32.2 =$	$10/9.8 =$	$20/0.45 =$
$\sqrt{64.32} =$	$\sqrt{1916} =$	$\sqrt{0.1916} =$
$1.35^{\frac{1}{2}} =$	$1.35^{\frac{1}{3}} =$	$1.35^{\frac{1}{4}} =$

CHAPTER 3

TABLES OF CIRCLES AND SPHERES

15. Areas of Circles for Diam-

<i>d</i>	0	1	2	3	4	5	6	7	8	9
1.0	0.785	0.801	0.817	0.833	0.849	0.866	0.882	0.899	0.916	0.933
1.1	0.950	0.968	0.985	1.003	1.021	1.039	1.057	1.075	1.094	1.112
1.2	1.131	1.150	1.169	1.188	1.208	1.227	1.247	1.267	1.287	1.307
1.3	1.327	1.348	1.368	1.389	1.410	1.431	1.453	1.474	1.496	1.517
1.4	1.539	1.561	1.584	1.606	1.629	1.651	1.674	1.697	1.720	1.744
1.5	1.767	1.791	1.815	1.839	1.863	1.887	1.911	1.936	1.961	1.986
1.6	2.011	2.036	2.061	2.087	2.112	2.138	2.164	2.190	2.217	2.243
1.7	2.270	2.297	2.324	2.351	2.378	2.405	2.433	2.461	2.488	2.516
1.8	2.545	2.573	2.602	2.630	2.659	2.688	2.717	2.746	2.776	2.806
1.9	2.835	2.865	2.895	2.926	2.956	2.986	3.017	3.048	3.079	3.110
2.0	3.142	3.173	3.205	3.237	3.269	3.301	3.333	3.365	3.398	3.431
2.1	3.464	3.497	3.530	3.563	3.597	3.631	3.664	3.698	3.733	3.767
2.2	3.801	3.836	3.871	3.906	3.941	3.976	4.012	4.047	4.083	4.119
2.3	4.155	4.191	4.227	4.264	4.301	4.337	4.374	4.412	4.449	4.486
2.4	4.524	4.562	4.600	4.638	4.676	4.714	4.753	4.792	4.831	4.870
2.5	4.909	4.948	4.988	5.027	5.067	5.107	5.147	5.187	5.228	5.269
2.6	5.309	5.350	5.391	5.433	5.474	5.515	5.557	5.599	5.641	5.683
2.7	5.726	5.768	5.811	5.853	5.896	5.940	5.983	6.026	6.070	6.114
2.8	6.158	6.202	6.246	6.290	6.335	6.379	6.424	6.469	6.514	6.560
2.9	6.605	6.651	6.697	6.743	6.789	6.835	6.881	6.928	6.975	7.022
3.0	7.069	7.116	7.163	7.211	7.258	7.306	7.354	7.402	7.451	7.499
3.1	7.548	7.596	7.645	7.694	7.744	7.793	7.843	7.892	7.942	7.992
3.2	8.042	8.093	8.143	8.194	8.245	8.296	8.347	8.398	8.450	8.501
3.3	8.553	8.605	8.657	8.709	8.762	8.814	8.867	8.920	8.973	9.026
3.4	9.079	9.133	9.186	9.240	9.294	9.348	9.402	9.457	9.511	9.566
3.5	9.621	9.676	9.731	9.787	9.842	9.898	9.954	10.01	10.07	10.12
3.6	10.18	10.24	10.29	10.35	10.41	10.46	10.52	10.58	10.64	10.69
3.7	10.75	10.81	10.87	10.93	10.99	11.04	11.10	11.16	11.22	11.28
3.8	11.34	11.40	11.46	11.52	11.58	11.64	11.70	11.76	11.82	11.88
3.9	11.95	12.01	12.07	12.13	12.19	12.25	12.32	12.38	12.44	12.50
4.0	12.57	12.63	12.69	12.76	12.82	12.88	12.95	13.01	13.07	13.14
4.1	13.20	13.27	13.33	13.40	13.46	13.53	13.59	13.66	13.72	13.79
4.2	13.85	13.92	13.99	14.05	14.12	14.19	14.25	14.32	14.39	14.45
4.3	14.52	14.59	14.66	14.73	14.79	14.86	14.93	15.00	15.07	15.14
4.4	15.21	15.27	15.34	15.41	15.48	15.55	15.62	15.69	15.76	15.83
4.5	15.90	15.98	16.05	16.12	16.19	16.26	16.33	16.40	16.47	16.55
4.6	16.62	16.69	16.76	16.84	16.91	16.98	17.06	17.13	17.20	17.28
4.7	17.35	17.42	17.50	17.57	17.65	17.72	17.80	17.87	17.95	18.02
4.8	18.10	18.17	18.25	18.32	18.40	18.47	18.55	18.63	18.70	18.78
4.9	18.86	18.93	19.01	19.09	19.17	19.24	19.32	19.40	19.48	19.56
5.0	19.63	19.71	19.79	19.87	19.95	20.03	20.11	20.19	20.27	20.35
5.1	20.43	20.51	20.59	20.67	20.75	20.83	20.91	20.99	21.07	21.16
5.2	21.24	21.32	21.40	21.48	21.57	21.65	21.73	21.81	21.90	21.98
5.3	22.06	22.15	22.23	22.31	22.40	22.48	22.56	22.65	22.73	22.82
5.4	22.90	22.99	23.07	23.16	23.24	23.33	23.41	23.50	23.59	23.67
<i>d</i>	0	1	2	3	4	5	6	7	8	9

eters in Units and Hundredths

<i>d</i>	0	1	2	3	4	5	6	7	8	9
5.5	23.76	23.84	23.93	24.02	24.11	24.19	24.28	24.37	24.45	24.54
5.6	24.63	24.72	24.81	24.89	24.98	25.07	25.16	25.25	25.34	25.43
5.7	25.52	25.61	25.70	25.79	25.88	25.97	26.06	26.15	26.24	26.33
5.8	26.42	26.51	26.60	26.69	26.79	26.88	26.97	27.06	27.15	27.25
5.9	27.34	27.43	27.53	27.62	27.71	27.81	27.90	27.99	28.09	28.18
6.0	28.27	28.37	28.46	28.56	28.65	28.75	28.84	28.94	29.03	29.13
6.1	29.22	29.32	29.42	29.51	29.61	29.71	29.80	29.90	30.00	30.09
6.2	30.19	30.29	30.39	30.48	30.58	30.68	30.78	30.88	30.97	31.07
6.3	31.17	31.27	31.37	31.47	31.57	31.67	31.77	31.87	31.97	32.07
6.4	32.17	32.27	32.37	32.47	32.57	32.67	32.78	32.88	32.98	33.08
6.5	33.18	33.29	33.39	33.49	33.59	33.70	33.80	33.90	34.00	34.11
6.6	34.21	34.32	34.42	34.52	34.63	34.73	34.84	34.94	35.05	35.15
6.7	35.26	35.36	35.47	35.57	35.68	35.78	35.89	36.00	36.10	36.21
6.8	36.32	36.42	36.53	36.64	36.75	36.85	36.96	37.07	37.18	37.28
6.9	37.39	37.50	37.61	37.72	37.83	37.94	38.05	38.16	38.26	38.37
7.0	38.48	38.59	38.70	38.82	38.93	39.04	39.15	39.26	39.37	39.48
7.1	39.59	39.70	39.82	39.93	40.04	40.15	40.26	40.38	40.49	40.60
7.2	40.72	40.83	40.94	41.06	41.17	41.28	41.40	41.51	41.62	41.74
7.3	41.85	41.97	42.08	42.20	42.31	42.43	42.54	42.66	42.78	42.89
7.4	43.01	43.12	43.24	43.36	43.47	43.59	43.71	43.83	43.94	44.06
7.5	44.18	44.30	44.41	44.53	44.65	44.77	44.89	45.01	45.13	45.25
7.6	45.36	45.48	45.60	45.72	45.84	45.96	46.08	46.20	46.32	46.45
7.7	46.57	46.69	46.81	46.93	47.05	47.17	47.29	47.42	47.54	47.66
7.8	47.78	47.91	48.03	48.15	48.27	48.40	48.52	48.65	48.77	48.89
7.9	49.02	49.14	49.27	49.39	49.51	49.64	49.76	49.89	50.01	50.14
8.0	50.27	50.39	50.52	50.64	50.77	50.90	51.02	51.15	51.28	51.40
8.1	51.53	51.66	51.78	51.91	52.04	52.17	52.30	52.42	52.55	52.68
8.2	52.81	52.94	53.07	53.20	53.33	53.46	53.59	53.72	53.85	53.98
8.3	54.11	54.24	54.37	54.50	54.63	54.76	54.89	55.02	55.15	55.29
8.4	55.42	55.55	55.68	55.81	55.95	56.08	56.21	56.35	56.48	56.61
8.5	56.75	56.88	57.01	57.15	57.28	57.41	57.55	57.68	57.82	57.95
8.6	58.09	58.22	58.36	58.49	58.63	58.77	58.90	59.04	59.17	59.31
8.7	59.45	59.58	59.72	59.86	59.99	60.13	60.27	60.41	60.55	60.68
8.8	60.82	60.96	61.10	61.24	61.38	61.51	61.65	61.79	61.93	62.07
8.9	62.21	62.35	62.49	62.63	62.77	62.91	63.05	63.19	63.33	63.48
9.0	63.62	63.76	63.90	64.04	64.18	64.33	64.47	64.61	64.75	64.90
9.1	65.04	65.18	65.33	65.47	65.61	65.76	65.90	66.04	66.19	66.33
9.2	66.48	66.62	66.77	66.91	67.06	67.20	67.35	67.49	67.64	67.78
9.3	67.93	68.08	68.22	68.37	68.51	68.66	68.81	68.96	69.10	69.25
9.4	69.40	69.55	69.69	69.84	69.99	70.14	70.29	70.44	70.58	70.73
9.5	70.88	71.03	71.18	71.33	71.48	71.63	71.78	71.93	72.08	72.23
9.6	72.38	72.53	72.68	72.84	72.99	73.14	73.29	73.44	73.59	73.75
9.7	73.90	74.05	74.20	74.36	74.51	74.66	74.82	74.97	75.12	75.28
9.8	75.43	75.58	75.74	75.89	76.05	76.20	76.36	76.51	76.67	76.82
9.9	76.98	77.13	77.29	77.44	77.60	77.76	77.91	78.07	78.23	78.38
<i>d</i>	0	1	2	3	4	5	6	7	8	9

16. Areas of Circles

Diameters in Units and Eighths

<i>d</i>	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8
0	0.0000	0.0123	0.0491	0.1104	0.1963	0.3068	0.4418	0.6013
1	0.7854	0.9940	1.2272	1.4849	1.7671	2.0739	2.4053	2.7612
2	3.1416	3.5466	3.9761	4.4301	4.9087	5.4119	5.9396	6.4918
3	7.0686	7.6699	8.2958	8.9462	9.6211	10.321	11.045	11.793
4	12.566	13.364	14.186	15.033	15.904	16.800	17.721	18.665
5	19.635	20.629	21.648	22.691	23.758	24.850	25.967	27.109
6	28.274	29.465	30.680	31.919	33.183	34.472	35.785	37.122
7	38.485	39.871	41.282	42.718	44.179	45.664	47.173	48.707
8	50.265	51.849	53.456	55.088	56.745	58.426	60.132	61.862
9	63.617	65.397	67.201	69.029	70.882	72.760	74.662	76.589
10	78.540	80.516	82.516	84.541	86.590	88.664	90.763	92.886
11	95.033	97.205	99.402	101.62	103.87	106.14	108.43	110.75
12	113.10	115.47	117.86	120.28	122.72	125.19	127.68	130.19
13	132.73	135.30	137.89	140.50	143.14	145.80	148.49	151.20
14	153.94	156.70	159.48	162.30	165.13	167.99	170.87	173.78
15	176.71	179.67	182.65	185.66	188.69	191.75	194.83	197.93
16	201.06	204.22	207.39	210.60	213.82	217.08	220.35	223.65
17	226.98	230.33	233.71	237.10	240.53	243.98	247.45	250.95
18	254.47	258.02	261.59	265.18	268.80	272.45	276.12	279.81
19	283.53	287.27	291.04	294.83	298.65	302.49	306.35	310.24
20	314.16	318.10	322.06	326.05	330.06	334.10	338.16	342.25
21	346.36	350.50	354.66	358.84	363.05	367.28	371.54	375.83
22	380.13	384.46	388.82	393.20	397.61	402.04	406.49	410.97
23	415.48	420.00	424.56	429.13	433.74	438.36	443.01	447.69
24	452.39	457.11	461.86	466.64	471.44	476.26	481.11	485.98
25	490.87	495.79	500.74	505.71	510.71	515.72	520.77	525.84
26	530.93	536.05	541.19	546.35	551.55	556.76	562.00	567.27
27	572.56	577.87	583.21	588.57	593.96	599.37	604.81	610.27
28	615.75	621.26	626.80	632.36	637.94	643.55	649.18	654.84
29	660.52	666.23	671.96	677.71	683.49	689.30	695.13	700.98
30	706.86	712.76	718.69	724.64	730.62	736.62	742.64	748.69
31	754.77	760.87	766.99	773.14	779.31	785.51	791.73	797.98
32	804.25	810.54	816.86	823.21	829.58	835.97	842.39	848.83
33	855.30	861.79	868.31	874.85	881.41	888.00	894.62	901.26
34	907.92	914.61	921.32	928.06	934.82	941.61	948.42	955.25
35	962.11	969.00	975.91	982.84	989.80	996.78	1003.8	1010.8
36	1017.9	1025.0	1032.1	1039.2	1046.3	1053.5	1060.7	1068.0
37	1075.2	1082.5	1089.8	1097.1	1104.5	1111.8	1119.2	1126.7
38	1134.1	1141.6	1149.1	1156.6	1164.2	1171.7	1179.3	1186.9
39	1194.6	1202.3	1210.0	1217.7	1225.4	1233.2	1241.0	1248.8
40	1256.6	1264.5	1272.4	1280.3	1288.2	1296.2	1304.2	1312.2
41	1320.3	1328.3	1336.4	1344.5	1352.7	1360.8	1369.0	1377.2
42	1385.4	1393.7	1402.0	1410.3	1418.6	1427.0	1435.4	1443.8
43	1452.2	1460.7	1469.1	1477.6	1486.2	1494.7	1503.3	1511.9
44	1520.5	1529.2	1537.9	1546.6	1555.3	1564.0	1572.8	1581.6
<i>d</i>	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8

17. Circumferences of Circles

Diameters in Units and Tenths

<i>d</i>	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	0.000	0.314	0.628	0.942	1.257	1.571	1.885	2.199	2.513	2.827
1	3.142	3.456	3.770	4.084	4.398	4.712	5.027	5.341	5.655	5.969
2	6.283	6.597	6.912	7.226	7.540	7.854	8.168	8.482	8.796	9.111
3	9.425	9.739	10.05	10.37	10.68	11.00	11.31	11.62	11.94	12.25
4	12.57	12.88	13.19	13.51	13.82	14.14	14.45	14.77	15.08	15.39
5	15.71	16.02	16.34	16.65	16.96	17.28	17.59	17.91	18.22	18.54
6	18.85	19.16	19.48	19.79	20.11	20.42	20.73	21.05	21.36	21.68
7	21.99	22.31	22.62	22.93	23.25	23.56	23.88	24.19	24.50	24.82
8	25.13	25.45	25.76	26.08	26.39	26.70	27.02	27.33	27.65	27.96
9	28.27	28.59	28.90	29.22	29.53	29.85	30.16	30.47	30.79	31.10
10	31.42	31.73	32.04	32.36	32.67	32.99	33.30	33.62	33.93	34.24
11	34.56	34.87	35.19	35.50	35.81	36.13	36.44	36.76	37.07	37.38
12	37.70	38.01	38.33	38.64	38.96	39.27	39.58	39.90	40.21	40.53
13	40.84	41.15	41.47	41.78	42.10	42.41	42.73	43.04	43.35	43.67
14	43.98	44.30	44.61	44.92	45.24	45.55	45.87	46.18	46.50	46.81
15	47.12	47.44	47.75	48.07	48.38	48.69	49.01	49.32	49.64	49.95
16	50.27	50.58	50.89	51.21	51.52	51.84	52.15	52.46	52.78	53.09
17	53.41	53.72	54.04	54.35	54.66	54.98	55.29	55.61	55.92	56.23
18	56.55	56.86	57.18	57.49	57.81	58.12	58.43	58.75	59.06	59.38
19	59.69	60.00	60.32	60.63	60.95	61.26	61.58	61.89	62.20	62.52

18. Circumferences of Circles

Diameters in Units and Eighths

<i>d</i>	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8
0	0.0000	0.3927	0.7854	1.1781	1.5708	1.9635	2.3562	2.7489
1	3.1416	3.5343	3.9270	4.3197	4.7124	5.1051	5.4978	5.8905
2	6.2832	6.6759	7.0686	7.4613	7.8540	8.2467	8.6394	9.0321
3	9.4248	9.8175	10.210	10.603	10.996	11.388	11.781	12.174
4	12.566	12.959	13.352	13.744	14.137	14.530	14.923	15.315
5	15.708	16.101	16.493	16.886	17.279	17.671	18.064	18.457
6	18.850	19.242	19.635	20.028	20.420	20.813	21.206	21.598
7	21.991	22.384	22.777	23.169	23.562	23.955	24.347	24.740
8	25.133	25.525	25.918	26.311	26.704	27.096	27.489	27.882
9	28.274	28.667	29.060	29.452	29.845	30.238	30.631	31.023
10	31.416	31.809	32.201	32.594	32.987	33.379	33.772	34.165
11	34.558	34.950	35.343	35.736	36.128	36.521	36.914	37.306
12	37.699	38.092	38.485	38.877	39.270	39.663	40.055	40.448
13	40.841	41.233	41.626	42.019	42.412	42.804	43.197	43.590
14	43.982	44.375	44.768	45.160	45.553	45.946	46.338	46.731
15	47.124	47.517	47.909	48.302	48.695	49.087	49.480	49.873
16	50.265	50.658	51.051	51.444	51.836	52.229	52.622	53.014
17	53.407	53.800	54.192	54.585	54.978	55.371	55.764	56.156
18	56.549	56.941	57.334	57.727	58.119	58.512	58.905	59.298
19	59.690	60.083	60.476	60.868	61.261	61.654	62.046	62.439

Central Angle Degrees	Length of Chord	Rise of Arc	Area of Segment	Central Angle Degrees	Length of Chord	Rise of Arc	Area of Segment
1	0.0175	0.0000	0.00000	46	0.7815	0.0795	0.04176
2	0.0349	0.0002	0.00000	47	0.7975	0.0829	0.04448
3	0.0524	0.0003	0.00001	48	0.8135	0.0865	0.04731
4	0.0698	0.0006	0.00003	49	0.8294	0.0900	0.05025
5	0.0872	0.0010	0.00006	50	0.8452	0.0937	0.05331
6	0.1047	0.0014	0.00010	51	0.8610	0.0974	0.05649
7	0.1221	0.0019	0.00015	52	0.8767	0.1012	0.05978
8	0.1395	0.0024	0.00023	53	0.8924	0.1051	0.06319
9	0.1569	0.0031	0.00032	54	0.9080	0.1090	0.06673
10	0.1743	0.0038	0.00044	55	0.9235	0.1130	0.07039
11	0.1917	0.0046	0.00059	56	0.9389	0.1171	0.07417
12	0.2091	0.0055	0.00076	57	0.9543	0.1212	0.07808
13	0.2264	0.0064	0.00097	58	0.9696	0.1254	0.08212
14	0.2437	0.0075	0.00121	59	0.9848	0.1296	0.08629
15	0.2611	0.0086	0.00149	60	1.0000	0.1340	0.09059
16	0.2783	0.0097	0.00181	61	1.0151	0.1384	0.09502
17	0.2956	0.0110	0.00217	62	1.0301	0.1428	0.09958
18	0.3129	0.0123	0.00257	63	1.0450	0.1474	0.10428
19	0.3301	0.0137	0.00302	64	1.0598	0.1520	0.10911
20	0.3473	0.0152	0.00352	65	1.0746	0.1566	0.11408
21	0.3645	0.0167	0.00408	66	1.0893	0.1613	0.11919
22	0.3816	0.0184	0.00468	67	1.1039	0.1661	0.12443
23	0.3987	0.0201	0.00535	68	1.1184	0.1710	0.12982
24	0.4158	0.0219	0.00607	69	1.1328	0.1759	0.13535
25	0.4329	0.0237	0.00686	70	1.1472	0.1808	0.14102
26	0.4499	0.0256	0.00771	71	1.1614	0.1859	0.14683
27	0.4669	0.0276	0.00862	72	1.1756	0.1910	0.15279
28	0.4838	0.0297	0.00961	73	1.1896	0.1961	0.15889
29	0.5008	0.0319	0.01067	74	1.2036	0.2014	0.16514
30	0.5176	0.0341	0.01180	75	1.2175	0.2066	0.17154
31	0.5345	0.0364	0.01301	76	1.2313	0.2120	0.17808
32	0.5512	0.0387	0.01429	77	1.2450	0.2174	0.18477
33	0.5680	0.0412	0.01566	78	1.2586	0.2229	0.19160
34	0.5847	0.0437	0.01711	79	1.2722	0.2284	0.19859
35	0.6014	0.0463	0.01864	80	1.2856	0.2340	0.20573
36	0.6180	0.0489	0.02027	81	1.2989	0.2396	0.21301
37	0.6346	0.0517	0.02198	82	1.3121	0.2453	0.22045
38	0.6511	0.0545	0.02378	83	1.3252	0.2510	0.22804
39	0.6676	0.0574	0.02568	84	1.3383	0.2569	0.23578
40	0.6840	0.0603	0.02767	85	1.3512	0.2627	0.24367
41	0.7004	0.0633	0.02976	86	1.3640	0.2686	0.25171
42	0.7167	0.0664	0.03195	87	1.3767	0.2746	0.25990
43	0.7330	0.0696	0.03425	88	1.3893	0.2807	0.26825
44	0.7492	0.0728	0.03664	89	1.4018	0.2867	0.27675
45	0.7654	0.0761	0.03915	90	1.4142	0.2929	0.28540

Segments

Central Angle Degrees	Length of Chord	Rise of Arc	Area of Segment	Central Angle Degrees	Length of Chord	Rise of Arc	Area of Segment
91	1.4265	0.2991	0.29420	136	1.8544	0.6254	0.83949
92	1.4387	0.3053	0.30316	137	1.8608	0.6335	0.85455
93	1.4507	0.3116	0.31226	138	1.8672	0.6416	0.86971
94	1.4627	0.3180	0.32152	139	1.8733	0.6498	0.88497
95	1.4746	0.3244	0.33093	140	1.8794	0.6580	0.90034
96	1.4863	0.3309	0.34050	141	1.8853	0.6662	0.91580
97	1.4979	0.3374	0.35021	142	1.8910	0.6744	0.93135
98	1.5094	0.3439	0.36008	143	1.8966	0.6827	0.94700
99	1.5208	0.3506	0.37009	144	1.9021	0.6910	0.96274
100	1.5321	0.3572	0.38026	145	1.9074	0.6993	0.97858
101	1.5432	0.3639	0.39058	146	1.9126	0.7076	0.99449
102	1.5543	0.3707	0.40104	147	1.9176	0.7160	1.01050
103	1.5652	0.3775	0.41166	148	1.9225	0.7244	1.02658
104	1.5760	0.3843	0.42242	149	1.9273	0.7328	1.04275
105	1.5867	0.3912	0.43333	150	1.9319	0.7412	1.05900
106	1.5973	0.3982	0.44439	151	1.9363	0.7496	1.07532
107	1.6077	0.4052	0.45560	152	1.9406	0.7581	1.09171
108	1.6180	0.4122	0.46695	153	1.9447	0.7666	1.10818
109	1.6282	0.4193	0.47844	154	1.9487	0.7750	1.12472
110	1.6383	0.4264	0.49008	155	1.9526	0.7836	1.14132
111	1.6483	0.4336	0.50187	156	1.9563	0.7921	1.15799
112	1.6581	0.4408	0.51379	157	1.9598	0.8006	1.17472
113	1.6678	0.4481	0.52586	158	1.9633	0.8092	1.19151
114	1.6773	0.4554	0.53807	159	1.9665	0.8178	1.20835
115	1.6868	0.4627	0.55041	160	1.9696	0.8264	1.22525
116	1.6961	0.4701	0.56289	161	1.9726	0.8350	1.24221
117	1.7053	0.4775	0.57551	162	1.9754	0.8436	1.25921
118	1.7143	0.4850	0.58827	163	1.9780	0.8522	1.27626
119	1.7233	0.4925	0.60116	164	1.9805	0.8608	1.29335
120	1.7321	0.5000	0.61418	165	1.9829	0.8695	1.31049
121	1.7407	0.5076	0.62734	166	1.9851	0.8781	1.32766
122	1.7492	0.5152	0.64063	167	1.9871	0.8868	1.34487
123	1.7576	0.5228	0.65404	168	1.9890	0.8955	1.36212
124	1.7659	0.5305	0.66759	169	1.9908	0.9042	1.37940
125	1.7740	0.5383	0.68125	170	1.9924	0.9128	1.39671
126	1.7820	0.5460	0.69505	171	1.9938	0.9215	1.41404
127	1.7899	0.5538	0.70897	172	1.9951	0.9302	1.43140
128	1.7976	0.5616	0.72301	173	1.9963	0.9390	1.44878
129	1.8052	0.5695	0.73716	174	1.9973	0.9477	1.46617
130	1.8126	0.5774	0.75144	175	1.9981	0.9564	1.48359
131	1.8199	0.5853	0.76584	176	1.9988	0.9651	1.50101
132	1.8271	0.5933	0.78034	177	1.9993	0.9738	1.51845
133	1.8341	0.6013	0.79497	178	1.9997	0.9825	1.53589
134	1.8410	0.6093	0.80970	179	1.9999	0.9913	1.55334
135	1.8478	0.6173	0.82454	180	2.0000	1.0000	1.57080

20. Volumes of Spheres

Diameters in Units and Tenths

d	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	0.000	0.001	0.004	0.014	0.034	0.065	0.113	0.180	0.268	0.382
1	0.524	0.697	0.905	1.150	1.437	1.767	2.145	2.572	3.054	3.591
2	4.189	4.849	5.575	6.371	7.238	8.181	9.203	10.31	11.49	12.77
3	14.14	15.60	17.16	18.82	20.58	22.45	24.43	26.52	28.73	31.06
4	33.51	36.09	38.79	41.63	44.60	47.71	50.97	54.36	57.91	61.60
5	65.45	69.46	73.62	77.95	82.45	87.11	91.95	96.97	102.2	107.5
6	113.1	118.8	124.8	130.9	137.3	143.8	150.5	157.5	164.6	172.0
7	179.6	187.4	195.4	203.7	212.2	220.9	229.8	239.0	248.5	258.2
8	268.1	278.3	288.7	299.4	310.3	321.6	333.0	344.8	356.8	369.1
9	381.7	394.6	407.7	421.2	434.9	448.9	463.2	477.9	492.8	508.0
10	523.6	539.5	555.6	572.2	589.0	606.1	623.6	641.4	659.6	678.1
11	696.9	716.1	735.6	755.5	775.7	796.3	817.3	838.6	860.3	882.3
12	904.8	927.6	950.8	974.3	998.3	1023	1047	1073	1098	1124
13	1150	1177	1204	1232	1260	1288	1317	1346	1376	1406
14	1437	1468	1499	1531	1563	1596	1630	1663	1697	1732
15	1767	1803	1839	1875	1912	1950	1988	2026	2065	2105
16	2145	2185	2226	2268	2310	2352	2395	2439	2483	2527
17	2572	2618	2664	2711	2758	2806	2855	2903	2953	3003
18	3054	3105	3157	3209	3262	3315	3369	3424	3479	3535
19	3591	3648	3706	3764	3823	3882	3942	4003	4064	4126

21. Volumes of Spheres

Diameters in Units and Eighths

d	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8
0	0.0000	0.0010	0.0082	0.0276	0.0654	0.1278	0.2209	0.3508
1	0.5236	0.7455	1.0227	1.3612	1.7671	2.2468	2.8062	3.4515
2	4.1888	5.0243	5.9641	7.0144	8.1812	9.4708	10.889	12.443
3	14.137	15.979	17.974	20.129	22.449	24.942	27.612	30.466
4	33.510	36.751	40.194	43.846	47.713	51.800	56.115	60.663
5	65.450	70.482	75.766	81.308	87.114	93.189	99.541	106.17
6	113.10	120.31	127.83	135.66	143.79	152.25	161.03	170.14
7	179.59	189.39	199.53	210.03	220.89	232.12	243.73	255.71
8	268.08	280.85	294.01	307.58	321.56	335.95	350.77	366.02
9	381.70	397.83	414.40	431.43	448.92	466.88	485.30	504.21
10	523.60	543.48	563.86	584.74	606.13	628.04	650.47	673.42
11	696.91	720.94	745.51	770.64	796.33	822.58	849.40	876.80
12	904.78	933.35	962.51	992.28	1022.7	1053.6	1085.2	1117.5
13	1150.3	1183.8	1218.0	1252.8	1288.2	1324.4	1361.2	1398.6
14	1436.8	1475.6	1515.1	1555.3	1596.3	1637.9	1680.3	1723.3
15	1767.1	1811.7	1857.0	1903.0	1949.8	1997.4	2045.7	2094.8
16	2144.7	2195.3	2246.8	2299.0	2352.1	2405.9	2460.6	2516.1
17	2572.4	2629.6	2687.6	2746.5	2806.2	2866.7	2928.2	2990.5
18	3053.6	3117.7	3182.6	3248.5	3315.2	3382.9	3451.5	3520.9
19	3591.4	3662.7	3735.0	3808.2	3882.4	3957.6	4033.7	4110.7

22. Multipliers for Finding Lengths of Circular Arcs

	Degrees	Minutes	Seconds	
1	0.017453293	0.000290888	0.000004848	<p>Example. Find length of arc for a central angle of $48^{\circ} 45'$ in circle of 12 ft. radius.</p> $ \begin{array}{r} 40^{\circ} \quad 0.698132 \\ 8^{\circ} \quad .139626 \\ 40' \quad .011636 \\ 5' \quad .001454 \\ \hline 0.85085 \\ \hline 12 \\ \hline \text{Length} = 10.210 \text{ ft} \end{array} $
2	0.034906585	0.000581776	0.000009696	
3	0.052359878	0.000872665	0.000014544	
4	0.069813170	0.001163553	0.000019393	
5	0.087266463	0.001454441	0.000024241	
6	0.104719755	0.001745329	0.000029089	
7	0.122173048	0.002036217	0.000033937	
8	0.139626340	0.002327106	0.000038785	
9	0.157079633	0.002617994	0.000043633	

23. Explanations

Table 15 gives Areas of Circles to four places for three-place diameters. Since the area of a circle varies as the square of its diameter, it follows that the decimal point moves two places in the function when it moves one place in the argument. Thus, for diameters of 4.53 and 45.3 inches the areas of the circles are 16.12 and 1612 square inches; for a diameter of 0.453 inches the area is 0.1612 square inches.

Table 16 gives Areas of Circles when the diameters are expressed in units and eighths; thus for a diameter of $22\frac{3}{8}$ inches, the area is 393.20 square inches. When the diameter is given to sixteenths the area is approximately half-way between the two nearest tabular values; thus, for a diameter of $2\frac{1}{16}$ inches the area is 3.34 square inches.

Tables 17 and 18 give Circumferences of Circles for diameters in tenths and eighths of units. For example, circles of 7.2 and $7\frac{1}{4}$ inches in diameter have circumferences of 22.62 and 22.78 inches.

Tables 17-18 can also be used for finding a diameter when the area or circumference is given. Examples: when the areas 50.52 and 51.34 are given the corresponding diameters are 8.02 and 8.085; when the circumferences 5.027 and 5.134 are given, the diameters are 1.600 and 1.634.

Table 19 gives properties of Segments of a Circle of radius unity. For any other radius r the tabular lengths of chord and

rise of arc are to be multiplied by r and the tabular area by r^2 . For example, when the radius is 20 feet and the angle at the center of the circle is 82° , the length of the chord of the segment is 26.242 feet, the rise of the arc is 4.906 feet, and the area of the segment is 88.18 square feet.

Tables 20 and 21 give Volumes of Spheres for diameters in tenths and eighths. Thus, for spheres 9.1 and $9\frac{1}{8}$ inches in diameter the volumes are 394.6 and 397.8 cubic inches.

Table 22 gives Multipliers for finding lengths of Circular Arcs of radius unity. Example: to find the length of a railroad curve of 700 feet radius and $60^\circ 8'$ central angle; here the table gives 1.0472 for 60° and 0.0023 for $8'$; adding these and multiplying by 700 gives 734.65 feet for the actual length of the curve.

24. Exercises

1. Find the areas of circles whose diameters are 3.4, 3.42, and 3.421 feet; also for diameters of 340, 342, and 342.1 feet.

2. Find the area for a circle of 19.25 inches diameter by interpolation in Table 15 and compare the result with that given in Table 16.

3. Find circumferences of circles 20.3 and 2.03 inches diameter; also of circles 40.6 and 4.06 feet diameter.

4. In a circle of 12 inches diameter the measured chord of a segment was 14.44 inches. What is the chord for a radius unity? By help of Table 19 find the central angle, the rise of the arc, and the area of the segment.

5. For a central angle of $48^\circ 30'$ find the length of chord, rise of arc, and area of segment in a circle whose radius is 60.5 centimeters.

6. What are the volumes of spheres of 0.34, 3.4, and 34 inches?

7. A cannon ball 8 inches in diameter has a specific gravity of 7.8. If the weight of a cubic foot of water is 62.5 pounds, what is the weight of the cannon ball?

8. Find the length of a railroad curve having a central angle of $3^\circ 15'$ and a radius of 5730 feet.

CHAPTER 4

NATURAL TRIGONOMETRIC FUNCTIONS

25. Natural Sines

SINE

Angle	0'	10'	20'	30'	40'	50'	60'	
0°	0.00000	0.00291	0.00582	0.00873	0.01164	0.01454	0.01745	89
1	0.01745	0.02036	0.02327	0.02618	0.02908	0.03199	0.03490	88
2	0.03490	0.03781	0.04071	0.04362	0.04653	0.04943	0.05234	87
3	0.05234	0.05524	0.05814	0.06105	0.06395	0.06685	0.06976	86
4	0.06976	0.07266	0.07556	0.07846	0.08136	0.08426	0.08716	85°
5°	0.08716	0.09005	0.09295	0.09585	0.09874	0.10164	0.10453	84
6	0.10453	0.10742	0.11031	0.11320	0.11609	0.11898	0.12187	83
7	0.12187	0.12476	0.12764	0.13053	0.13341	0.13629	0.13917	82
8	0.13917	0.14205	0.14493	0.14781	0.15069	0.15356	0.15643	81
9	0.15643	0.15931	0.16218	0.16505	0.16792	0.17078	0.17365	80°
10°	0.17365	0.17651	0.17937	0.18224	0.18509	0.18795	0.19081	79
11	0.19081	0.19366	0.19652	0.19937	0.20222	0.20507	0.20791	78
12	0.20791	0.21076	0.21360	0.21644	0.21928	0.22212	0.22495	77
13	0.22495	0.22778	0.23062	0.23345	0.23627	0.23910	0.24192	76
14	0.24192	0.24474	0.24756	0.25038	0.25320	0.25601	0.25882	75°
15°	0.25882	0.26163	0.26443	0.26724	0.27004	0.27284	0.27564	74
16	0.27564	0.27843	0.28123	0.28402	0.28680	0.28959	0.29237	73
17	0.29237	0.29515	0.29793	0.30071	0.30348	0.30625	0.30902	72
18	0.30902	0.31178	0.31454	0.31730	0.32006	0.32282	0.32557	71
19	0.32557	0.32832	0.33106	0.33381	0.33655	0.33929	0.34202	70°
20°	0.34202	0.34475	0.34748	0.35021	0.35293	0.35565	0.35837	69
21	0.35837	0.36108	0.36379	0.36650	0.36921	0.37191	0.37461	68
22	0.37461	0.37730	0.37999	0.38268	0.38537	0.38805	0.39073	67
23	0.39073	0.39341	0.39608	0.39875	0.40142	0.40408	0.40674	66
24	0.40674	0.40939	0.41204	0.41469	0.41734	0.41998	0.42262	65°
25°	0.42262	0.42525	0.42788	0.43051	0.43313	0.43575	0.43837	64
26	0.43837	0.44098	0.44359	0.44620	0.44880	0.45140	0.45399	63
27	0.45399	0.45658	0.45917	0.46175	0.46433	0.46690	0.46947	62
28	0.46947	0.47204	0.47460	0.47716	0.47971	0.48226	0.48481	61
29	0.48481	0.48735	0.48989	0.49242	0.49495	0.49748	0.50000	60°
30°	0.50000	0.50252	0.50503	0.50754	0.51004	0.51254	0.51504	59
31	0.51504	0.51753	0.52002	0.52250	0.52498	0.52745	0.52992	58
32	0.52992	0.53238	0.53484	0.53730	0.53975	0.54220	0.54464	57
33	0.54464	0.54708	0.54951	0.55194	0.55436	0.55678	0.55919	56
34	0.55919	0.56160	0.56401	0.56641	0.56880	0.57119	0.57358	55°
35°	0.57358	0.57596	0.57833	0.58070	0.58307	0.58543	0.58779	54
36	0.58779	0.59014	0.59248	0.59482	0.59716	0.59949	0.60182	53
37	0.60182	0.60414	0.60645	0.60876	0.61107	0.61337	0.61566	52
38	0.61566	0.61795	0.62024	0.62251	0.62479	0.62706	0.62932	51
39	0.62932	0.63158	0.63383	0.63608	0.63832	0.64056	0.64279	50°
40°	0.64279	0.64501	0.64723	0.64945	0.65166	0.65386	0.65606	49
41	0.65606	0.65825	0.66044	0.66262	0.66480	0.66697	0.66913	48
42	0.66913	0.67129	0.67344	0.67559	0.67773	0.67987	0.68200	47
43	0.68200	0.68412	0.68624	0.68835	0.69046	0.69256	0.69466	46
44	0.69466	0.69675	0.69883	0.70091	0.70298	0.70505	0.70711	45
	60'	50'	40'	30'	20'	10'	0'	Angle

COSINE

and Cosines

SINE

Angle	0'	10'	20'	30'	40'	50'	60'	
45°	0.70711	0.70916	0.71121	0.71325	0.71529	0.71732	0.71934	44
46	0.71934	0.72136	0.72337	0.72537	0.72737	0.72937	0.73135	43
47	0.73135	0.73333	0.73531	0.73728	0.73924	0.74120	0.74314	42
48	0.74314	0.74509	0.74703	0.74896	0.75088	0.75280	0.75471	41
49	0.75471	0.75661	0.75851	0.76041	0.76229	0.76417	0.76604	40°
50°	0.76604	0.76791	0.76977	0.77162	0.77347	0.77531	0.77715	39
51	0.77715	0.77897	0.78079	0.78261	0.78442	0.78622	0.78801	38
52	0.78801	0.78980	0.79158	0.79335	0.79512	0.79688	0.79864	37
53	0.79864	0.80038	0.80212	0.80386	0.80558	0.80730	0.80902	36
54	0.80902	0.81072	0.81242	0.81412	0.81580	0.81748	0.81915	35°
55°	0.81915	0.82082	0.82248	0.82413	0.82577	0.82741	0.82904	34
56	0.82904	0.83066	0.83228	0.83389	0.83549	0.83708	0.83867	33
57	0.83867	0.84025	0.84182	0.84339	0.84495	0.84650	0.84805	32
58	0.84805	0.84959	0.85112	0.85264	0.85416	0.85567	0.85717	31
59	0.85717	0.85866	0.86015	0.86163	0.86310	0.86457	0.86603	30°
60°	0.86603	0.86748	0.86892	0.87036	0.87178	0.87321	0.87462	29
61	0.87462	0.87603	0.87743	0.87882	0.88020	0.88158	0.88295	28
62	0.88295	0.88431	0.88566	0.88701	0.88835	0.88968	0.89101	27
63	0.89101	0.89232	0.89363	0.89493	0.89623	0.89752	0.89879	26
64	0.89879	0.90007	0.90133	0.90259	0.90383	0.90507	0.90631	25°
65°	0.90631	0.90753	0.90875	0.90996	0.91116	0.91236	0.91355	24
66	0.91355	0.91472	0.91590	0.91706	0.91822	0.91936	0.92050	23
67	0.92050	0.92164	0.92276	0.92388	0.92499	0.92609	0.92718	22
68	0.92718	0.92827	0.92935	0.93042	0.93148	0.93253	0.93358	21
69	0.93358	0.93462	0.93565	0.93667	0.93769	0.93869	0.93969	20°
70°	0.93969	0.94068	0.94167	0.94264	0.94361	0.94457	0.94552	19
71	0.94552	0.94646	0.94740	0.94832	0.94924	0.95015	0.95106	18
72	0.95106	0.95195	0.95284	0.95372	0.95459	0.95545	0.95630	17
73	0.95630	0.95715	0.95799	0.95882	0.95964	0.96046	0.96126	16
74	0.96126	0.96206	0.96285	0.96363	0.96440	0.96517	0.96593	15°
75°	0.96593	0.96667	0.96742	0.96815	0.96887	0.96959	0.97030	14
76	0.97030	0.97100	0.97169	0.97237	0.97304	0.97371	0.97437	13
77	0.97437	0.97502	0.97566	0.97630	0.97692	0.97754	0.97815	12
78	0.97815	0.97875	0.97934	0.97992	0.98050	0.98107	0.98163	11
79	0.98163	0.98218	0.98272	0.98325	0.98378	0.98430	0.98481	10°
80°	0.98481	0.98531	0.98580	0.98629	0.98676	0.98723	0.98769	9
81	0.98769	0.98814	0.98858	0.98902	0.98944	0.98986	0.99027	8
82	0.99027	0.99067	0.99106	0.99144	0.99182	0.99219	0.99255	7
83	0.99255	0.99290	0.99324	0.99357	0.99390	0.99421	0.99452	6
84	0.99452	0.99482	0.99511	0.99540	0.99567	0.99594	0.99619	5°
85°	0.99619	0.99644	0.99668	0.99692	0.99714	0.99736	0.99756	4
86	0.99756	0.99776	0.99795	0.99813	0.99831	0.99847	0.99863	3
87	0.99863	0.99878	0.99892	0.99905	0.99917	0.99929	0.99939	2
88	0.99939	0.99949	0.99958	0.99966	0.99973	0.99979	0.99985	1
89	0.99985	0.99989	0.99993	0.99996	0.99998	1.00000	1.00000	0°
	60'	50'	40'	30'	20'	10'	0'	Angle

COSINE

TANGENT

Angle	0'	10'	20'	30'	40'	50'	60'	
0°	0.00000	0.00291	0.00582	0.00873	0.01164	0.01455	0.01746	89
1	0.01746	0.02036	0.02328	0.02619	0.02910	0.03201	0.03492	88
2	0.03492	0.03783	0.04075	0.04366	0.04658	0.04949	0.05241	87
3	0.05241	0.05533	0.05824	0.06116	0.06408	0.06700	0.06993	86
4	0.06993	0.07285	0.07578	0.07870	0.08163	0.08456	0.08749	85°
5°	0.08749	0.09042	0.09335	0.09629	0.09923	0.10216	0.10510	84
6	0.10510	0.10805	0.11099	0.11394	0.11688	0.11983	0.12278	83
7	0.12278	0.12574	0.12869	0.13165	0.13461	0.13758	0.14054	82
8	0.14054	0.14351	0.14648	0.14945	0.15243	0.15540	0.15838	81
9	0.15838	0.16137	0.16435	0.16734	0.17033	0.17333	0.17633	80°
10°	0.17633	0.17933	0.18233	0.18534	0.18835	0.19136	0.19438	79
11	0.19438	0.19740	0.20042	0.20345	0.20648	0.20952	0.21256	78
12	0.2125	0.21560	0.21864	0.22169	0.22475	0.22781	0.23087	77
13	0.23087	0.23393	0.23700	0.24008	0.24316	0.24624	0.24933	76
14	0.24933	0.25242	0.25552	0.25862	0.26172	0.26483	0.26795	75°
15°	0.26795	0.27107	0.27419	0.27732	0.28046	0.28360	0.28675	74
16	0.28675	0.28990	0.29305	0.29621	0.29938	0.30255	0.30573	73
17	0.30573	0.30891	0.31210	0.31530	0.31850	0.32171	0.32492	72
18	0.32492	0.32814	0.33136	0.33460	0.33783	0.34108	0.34433	71
19	0.34433	0.34758	0.35085	0.35412	0.35740	0.36068	0.36397	70°
20°	0.36397	0.36727	0.37057	0.37388	0.37720	0.38053	0.38386	69
21	0.38386	0.38721	0.39055	0.39391	0.39727	0.40065	0.40403	68
22	0.40403	0.40741	0.41081	0.41421	0.41763	0.42105	0.42447	67
23	0.42447	0.42791	0.43136	0.43481	0.43828	0.44175	0.44523	66
24	0.44523	0.44872	0.45222	0.45573	0.45924	0.46277	0.46631	65°
25°	0.46631	0.46985	0.47341	0.47698	0.48055	0.48414	0.48773	64
26	0.48773	0.49134	0.49495	0.49858	0.50222	0.50587	0.50953	63
27	0.50953	0.51320	0.51688	0.52057	0.52427	0.52798	0.53171	62
28	0.53171	0.53545	0.53920	0.54296	0.54673	0.55051	0.55431	61
29	0.55431	0.55812	0.56194	0.56577	0.56962	0.57348	0.57735	60°
30°	0.57735	0.58124	0.58513	0.58905	0.59297	0.59691	0.60086	59
31	0.60086	0.60483	0.60881	0.61280	0.61681	0.62083	0.62487	58
32	0.62487	0.62892	0.63299	0.63707	0.64117	0.64528	0.64941	57
33	0.64941	0.65355	0.65771	0.66189	0.66608	0.67028	0.67451	56
34	0.67451	0.67875	0.68301	0.68728	0.69157	0.69588	0.70021	55°
35°	0.70021	0.70455	0.70891	0.71329	0.71769	0.72211	0.72654	54
36	0.72654	0.73100	0.73547	0.73996	0.74447	0.74900	0.75355	53
37	0.75355	0.75812	0.76272	0.76733	0.77196	0.77661	0.78129	52°
38	0.78129	0.78598	0.79070	0.79544	0.80020	0.80498	0.80978	51
39	0.80978	0.81461	0.81946	0.82434	0.82923	0.83415	0.83910	50°
40°	0.83910	0.84407	0.84906	0.85408	0.85912	0.86419	0.86929	49
41	0.86929	0.87441	0.87955	0.88473	0.88992	0.89515	0.90040	48
42	0.90040	0.90569	0.91099	0.91633	0.92170	0.92709	0.93252	47
43	0.93252	0.93797	0.94345	0.94896	0.95451	0.96008	0.96569	46
44	0.96569	0.97133	0.97700	0.98270	0.98843	0.99420	1.00000	45°
	60'	50'	40'	30'	20'	10'	0'	Angle

COTANGENT

and Cotangents

TANGENT

Angle	0'	10'	20'	30'	40'	50'	60'	
45°	1.00000	1.00583	1.01170	1.01761	1.02355	1.02952	1.03553	44
46	1.03553	1.04158	1.04766	1.05378	1.05994	1.06613	1.07237	43
47	1.07237	1.07864	1.08496	1.09131	1.09770	1.10414	1.11061	42
48	1.11061	1.11713	1.12369	1.13029	1.13694	1.14363	1.15037	41
49	1.15037	1.15715	1.16398	1.17085	1.17777	1.18474	1.19175	40°
50°	1.19175	1.19882	1.20593	1.21310	1.22031	1.22758	1.23490	39
51	1.23490	1.24227	1.24969	1.25717	1.26471	1.27230	1.27994	38
52	1.27994	1.28764	1.29541	1.30323	1.31110	1.31904	1.32704	37
53	1.32704	1.33511	1.34323	1.35142	1.35968	1.36800	1.37638	36
54	1.37638	1.38484	1.39336	1.40195	1.41061	1.41934	1.42815	35°
55°	1.42815	1.43703	1.44598	1.45501	1.46411	1.47330	1.48256	34
56	1.48256	1.49190	1.50133	1.51084	1.52043	1.53010	1.53987	33
57	1.53987	1.54972	1.55966	1.56969	1.57981	1.59002	1.60033	32
58	1.60033	1.61074	1.62125	1.63185	1.64256	1.65337	1.66428	31
59	1.66428	1.67530	1.68643	1.69766	1.70901	1.72047	1.73205	30°
60°	1.73205	1.74375	1.75556	1.76749	1.77955	1.79174	1.80405	29
61	1.80405	1.81649	1.82906	1.84177	1.85462	1.86760	1.88073	28
62	1.88073	1.89400	1.90741	1.92098	1.93470	1.94858	1.96261	27
63	1.96261	1.97680	1.99116	2.00569	2.02039	2.03526	2.05030	26
64	2.05030	2.06553	2.08094	2.09654	2.11233	2.12832	2.14451	25°
65°	2.14451	2.16090	2.17749	2.19430	2.21132	2.22857	2.24604	24
66	2.24604	2.26374	2.28167	2.29984	2.31826	2.33693	2.35585	23
67	2.35585	2.37504	2.39449	2.41421	2.43422	2.45451	2.47509	22
68	2.47509	2.49597	2.51715	2.53865	2.56046	2.58261	2.60509	21
69	2.60509	2.62791	2.65109	2.67462	2.69853	2.72281	2.74748	20°
70°	2.74748	2.77254	2.79802	2.82391	2.85023	2.87700	2.90421	19
71	2.90421	2.93189	2.96004	2.98869	3.01783	3.04749	3.07768	18
72	3.07768	3.10842	3.13972	3.17159	3.20406	3.23714	3.27085	17
73	3.27085	3.30521	3.34023	3.37594	3.41236	3.44951	3.48741	16
74	3.48741	3.52609	3.56557	3.60588	3.64705	3.68909	3.73205	15°
75°	3.73205	3.77595	3.82083	3.86671	3.91364	3.96165	4.01078	14
76	4.01078	4.06107	4.11256	4.16530	4.21933	4.27471	4.33148	13
77	4.33148	4.38969	4.44942	4.51071	4.57363	4.63825	4.70463	12
78	4.70463	4.77286	4.84300	4.91516	4.98940	5.06584	5.14455	11
79	5.14455	5.22566	5.30928	5.39552	5.48451	5.57638	5.67128	10°
80°	5.67128	5.76937	5.87080	5.97576	6.08444	6.19703	6.31375	9
81	6.31375	6.43484	6.56055	6.69116	6.82694	6.96823	7.11537	8
82	7.11537	7.26873	7.42871	7.59575	7.77035	7.95302	8.14435	7
83	8.14435	8.34496	8.55555	8.77689	9.00983	9.25530	9.51436	6
84	9.51436	9.78817	10.0780	10.3854	10.7119	11.0594	11.4301	5°
85°	11.4301	11.8262	12.2505	12.7062	13.1969	13.7267	14.3007	4
86	14.3007	14.9244	15.6048	16.3499	17.1693	18.0750	19.0811	3
87	19.0811	20.2056	21.4704	22.9038	24.5418	26.4316	28.6363	2
88	28.6363	31.2416	34.3678	38.1885	42.9641	49.1039	57.2900	1
89	57.2900	68.7501	85.9398	114.589	171.885	343.774	∞	0°
	60'	50'	40'	30'	20'	10'	0'	Angle

COTANGENT

27. Natural Trigonometric Functions

Angle	Arc	Sin	Tan	Sec	Cosec	Cot	Cos		
1°	0.0175	0.0175	0.0175	1.0002	57.299	57.290	0.9998	1.5533	89
2	0.0349	0.0349	0.0349	1.0006	28.654	28.636	0.9994	1.5359	88
3	0.0524	0.0523	0.0524	1.0014	19.107	19.081	0.9986	1.5184	87
4	0.0698	0.0698	0.0699	1.0024	14.336	14.301	0.9976	1.5010	86
5	0.0873	0.0872	0.0875	1.0038	11.474	11.430	0.9962	1.4835	85°
6°	0.1047	0.1045	0.1051	1.0055	9.5668	9.5144	0.9945	1.4661	84
7	0.1222	0.1219	0.1228	1.0075	8.2055	8.1443	0.9925	1.4486	83
8	0.1396	0.1392	0.1405	1.0098	7.1853	7.1154	0.9903	1.4312	82
9	0.1571	0.1564	0.1584	1.0125	6.3925	6.3138	0.9877	1.4137	81
10	0.1745	0.1736	0.1763	1.0154	5.7588	5.6713	0.9848	1.3963	80°
11°	0.1920	0.1908	0.1944	1.0187	5.2408	5.1446	0.9816	1.3788	79
12	0.2094	0.2079	0.2126	1.0223	4.8097	4.7046	0.9781	1.3614	78
13	0.2269	0.2250	0.2309	1.0263	4.4454	4.3315	0.9744	1.3439	77
14	0.2443	0.2419	0.2493	1.0306	4.1336	4.0108	0.9703	1.3265	76
15	0.2618	0.2588	0.2679	1.0353	3.8637	3.7321	0.9659	1.3090	75°
16°	0.2793	0.2756	0.2867	1.0403	3.6280	3.4874	0.9613	1.2915	74
17	0.2967	0.2924	0.3057	1.0457	3.4203	3.2709	0.9563	1.2741	73
18	0.3142	0.3090	0.3249	1.0515	3.2361	3.0777	0.9511	1.2566	72
19	0.3316	0.3256	0.3443	1.0576	3.0716	2.9042	0.9455	1.2392	71
20	0.3491	0.3420	0.3640	1.0642	2.9238	2.7475	0.9397	1.2217	70°
21°	0.3665	0.3584	0.3839	1.0711	2.7904	2.6051	0.9336	1.2043	69
22	0.3840	0.3746	0.4040	1.0785	2.6695	2.4751	0.9272	1.1868	68
23	0.4014	0.3907	0.4245	1.0864	2.5593	2.3559	0.9205	1.1694	67
24	0.4189	0.4067	0.4452	1.0946	2.4586	2.2460	0.9135	1.1519	66
25	0.4363	0.4226	0.4663	1.1034	2.3662	2.1445	0.9063	1.1345	65°
26°	0.4538	0.4384	0.4877	1.1126	2.2812	2.0503	0.8988	1.1170	64
27	0.4712	0.4540	0.5095	1.1223	2.2027	1.9626	0.8910	1.0996	63
28	0.4887	0.4695	0.5317	1.1326	2.1301	1.8807	0.8829	1.0821	62
29	0.5061	0.4848	0.5543	1.1434	2.0627	1.8040	0.8746	1.0647	61
30	0.5236	0.5000	0.5774	1.1547	2.0000	1.7321	0.8660	1.0472	60°
31°	0.5411	0.5150	0.6009	1.1666	1.9416	1.6643	0.8572	1.0297	59
32	0.5585	0.5299	0.6249	1.1792	1.8871	1.6003	0.8480	1.0123	58
33	0.5760	0.5446	0.6494	1.1924	1.8361	1.5399	0.8387	0.9948	57
34	0.5934	0.5592	0.6745	1.2062	1.7883	1.4826	0.8290	0.9774	56
35	0.6109	0.5736	0.7002	1.2208	1.7434	1.4281	0.8192	0.9599	55°
36°	0.6283	0.5878	0.7265	1.2361	1.7013	1.3764	0.8090	0.9425	54
37	0.6458	0.6018	0.7536	1.2521	1.6616	1.3270	0.7986	0.9250	53
38	0.6632	0.6157	0.7813	1.2690	1.6243	1.2799	0.7880	0.9076	52
39	0.6807	0.6293	0.8098	1.2868	1.5890	1.2349	0.7771	0.8901	51
40	0.6981	0.6428	0.8391	1.3054	1.5557	1.1918	0.7660	0.8727	50°
41°	0.7156	0.6561	0.8693	1.3250	1.5243	1.1504	0.7547	0.8552	49
42	0.7330	0.6691	0.9004	1.3456	1.4945	1.1106	0.7431	0.8378	48
43	0.7505	0.6820	0.9325	1.3673	1.4663	1.0724	0.7314	0.8203	47
44	0.7679	0.6947	0.9657	1.3902	1.4396	1.0355	0.7193	0.8029	46
45	0.7854	0.7071	1.0000	1.4142	1.4142	1.0000	0.7071	0.7854	45°
		Cos	Cot	Cosec	Sec	Tan	Sin	Arc	Angle

28. Explanations

Table 25 gives Natural Sines and Cosines of angles for every 10 minutes from $0^\circ 0'$ to $90^\circ 0'$. When the sine is sought, the angle, or argument, is to be looked for at the left-hand side and at the top of the page; when the cosine is sought, the angle is to be looked for at the right-hand side and at the foot of the page. Thus the sine of $64^\circ 50'$ is 0.90507, but the cosine of $64^\circ 50'$ is 0.42525. Again, the number 0.36108 is seen to be the sine of $21^\circ 10'$ or the cosine of $68^\circ 50'$.

Table 26, which is arranged like table 25, gives Natural Tangents and Cotangents of angles.

Interpolation in these tables can be made for a given angle like $13^\circ 27'$ as explained in Art. 3, but the last figure of the function may be sometimes one unit in error for the sine and cosine, and more than one unit for a tangent of an angle greater than 60° or for a cotangent of an angle less than 30° . For example the table gives $\sin 14^\circ 12' = 0.24530$ and $\cot 14^\circ 12' = 3.95205$, the former being in error one unit in the last place and the latter nine units.

Table 27 gives all common Trigonometric Functions to four places. Here Arc is the length of the arc of the angle in a circle of radius unity; thus $\text{arc } 25^\circ = 0.4363$, as may be otherwise found from Table 22. The secant is the reciprocal of the cosine and the cosecant of the sine. Interpolation need rarely be made in this table. When the angle is less than 45° look for it at the left-hand side of the table and for the name of the functions at the top; for angles between 45° and 90° look for the angle at right-hand side and for the name of the function at the foot. Thus, $\sin 41^\circ = 0.6561$, $\cos 50^\circ = 0.6428$, $\sec 75^\circ = 3.8637$.

Inverse Interpolation is the process of finding an argument from a given value of a function. If the sine be given as 0.70916, the corresponding angle is seen from Table 25 to be $45^\circ 10'$, and here no interpolation is necessary. But let the sine 0.70987 be given, then the angle is seen to lie between $45^\circ 10'$ and $45^\circ 20'$; the difference of the sines of these angles is 0.00205, hence the

difference for $1'$ is 0.000205; now the given sine is greater than the sine of $45^\circ 10'$ by 0.00071, then $71/20.7 = 3.5$, so that the required angle is $45^\circ 13.5'$. It is important to note whether or not the values of the function increase with the argument; thus, if the cosine 0.94698 be given, the angle is seen to be less than $18^\circ 50'$ and more than $18^\circ 40'$, so that the computed difference is to be subtracted; here the angle will be found to be $18^\circ 47'$ closely.

29. Exercises

1. Find the values of the following functions to five decimal places:

$\sin 25^\circ 20' =$	$\cos 25^\circ 20' =$
$\sin 85^\circ 40' =$	$\cos 85^\circ 40' =$
$\sin 77^\circ 34' =$	$\cos 77^\circ 34' =$

2. Find the angle whose sine is 0.39700. Also the angle whose tangent is 1.24312.

3. Find the values of the following functions to four decimal places:

$\sin 30^\circ =$	$\cos 30^\circ =$	$\tan 30^\circ =$
$\sin 60^\circ =$	$\cos 60^\circ =$	$\tan 60^\circ =$
$\sec 30^\circ =$	$\operatorname{cosec} 60^\circ =$	$\operatorname{arc} 60^\circ =$

4. Multiply the tangent of $11^\circ 20'$ by the cotangent of the same angle.

5. Find $\sin 45^\circ$ and $\cos 45^\circ$ by Table 27, and then multiply them together.

6. Find the sine and cosine of 17° , square each by help of Table 7, and then add these squares.

7. Find the value of $\operatorname{arc} 78^\circ$ by Table 22 and also by Table 27.

8. Find the values of the following functions to five decimal places:

$\cos 32^\circ 33' =$	$\cot 32^\circ 33' =$
$\sin 57^\circ 27' =$	$\tan 57^\circ 27' =$
$\cot 40^\circ 15' =$	$\cot 49^\circ 45' =$

9. Test the equation $\cos^2 \theta - \sin^2 \theta = \cos 2\theta$ by assuming a value of θ , taking the functions from Table 27, and the squares from Table 7.

10. A vertical post 3.64 feet high casts a shadow 10.0 feet long on level ground. How high is the sun above the horizon?

11. Find the (angles whose sines are 0.5000, 0.8660, and 0.9979; also the angles whose tangents are 0.1, 0.3, 0.5, 0.7, and 0.9; also the angles whose tangents are 1.0, 2.0, 3.0, and 4.0.

CHAPTER 5

LOGARITHMIC TABLES

30. Common Logarithms

n	0	1	2	3	4	5	6	7	8	9
10	00000	00432	00860	01284	01703	02119	02531	02938	03342	03743
11	04139	04532	04922	05308	05690	06070	06446	06819	07188	07555
12	07918	08279	08636	08991	09342	09691	10037	10380	10721	11059
13	11394	11727	12057	12385	12710	13033	13354	13672	13988	14301
14	14613	14922	15229	15534	15836	16137	16435	16732	17026	17319
15	17609	17898	18184	18469	18752	19033	19312	19590	19866	20140
16	20412	20683	20952	21219	21484	21748	22011	22272	22531	22789
17	23045	23300	23553	23805	24055	24304	24551	24797	25042	25285
18	25527	25768	26007	26245	26482	26717	26951	27184	27416	27646
19	27875	28103	28330	28556	28780	29003	29226	29447	29667	29885
20	30103	30320	30535	30750	30963	31175	31387	31597	31806	32015
21	32222	32428	32634	32838	33041	33244	33445	33646	33846	34044
22	34242	34439	34635	34830	35025	35218	35411	35603	35793	35984
23	36173	36361	36549	36736	36922	37107	37291	37475	37658	37840
24	38021	38202	38382	38561	38739	38917	39094	39270	39445	39620
25	39794	39967	40140	40312	40483	40654	40824	40993	41162	41330
26	41497	41664	41830	41996	42160	42325	42488	42651	42813	42975
27	43136	43297	43457	43616	43775	43933	44091	44248	44404	44560
28	44716	44871	45025	45179	45332	45484	45637	45788	45939	46090
29	46240	46389	46538	46687	46835	46982	47129	47276	47422	47567
30	47712	47857	48001	48144	48287	48430	48572	48714	48855	48996
31	49136	49276	49415	49554	49693	49831	49969	50106	50243	50379
32	50515	50651	50786	50920	51055	51188	51322	51455	51587	51720
33	51851	51983	52114	52244	52375	52504	52634	52763	52892	53020
34	53148	53275	53403	53529	53656	53782	53908	54033	54158	54283
35	54407	54531	54654	54777	54900	55023	55145	55267	55388	55509
36	55630	55751	55871	55991	56110	56229	56348	56467	56585	56703
37	56820	56937	57054	57171	57287	57403	57519	57634	57749	57864
38	57978	58092	58206	58320	58433	58546	58659	58771	58883	58995
39	59106	59218	59329	59439	59550	59660	59770	59879	59988	60097
40	60206	60314	60423	60531	60638	60746	60853	60959	61066	61172
41	61278	61384	61490	61595	61700	61805	61909	62014	62118	62221
42	62325	62428	62531	62634	62737	62839	62941	63043	63144	63246
43	63347	63448	63548	63649	63749	63849	63949	64048	64147	64246
44	64345	64444	64542	64640	64738	64836	64933	65031	65128	65225
45	65321	65418	65514	65610	65706	65801	65896	65992	66087	66181
46	66276	66370	66464	66558	66652	66745	66839	66932	67025	67117
47	67210	67302	67394	67486	67578	67669	67761	67852	67943	68034
48	68124	68215	68305	68395	68485	68574	68664	68753	68842	68931
49	69020	69108	69197	69285	69373	69461	69548	69636	69723	69810
50	69897	69984	70070	70157	70243	70329	70415	70501	70586	70672
51	70757	70842	70927	71012	71096	71181	71265	71349	71433	71517
52	71600	71684	71767	71850	71933	72016	72099	72181	72263	72346
53	72428	72509	72591	72673	72754	72835	72916	72997	73078	73159
54	73239	73320	73400	73480	73560	73640	73719	73799	73878	73957
	0	1	2	3	4	5	6	7	8	9

of Numbers from 000 to 999

n	0	1	2	3	4	5	6	7	8	9
55	74036	74115	74194	74273	74351	74429	74507	74586	74663	74741
56	74819	74896	74974	75051	75128	75205	75282	75358	75435	75511
57	75587	75664	75740	75815	75891	75967	76042	76118	76193	76268
58	76343	76418	76492	76567	76641	76716	76790	76864	76938	77012
59	77085	77159	77232	77305	77379	77452	77525	77597	77670	77743
60	77815	77887	77960	78032	78104	78176	78247	78319	78390	78462
61	78533	78604	78675	78746	78817	78888	78958	79029	79099	79169
62	79239	79309	79379	79449	79518	79588	79657	79727	79796	79865
63	79934	80003	80072	80140	80209	80277	80346	80414	80482	80550
64	80618	80686	80754	80821	80889	80956	81023	81090	81158	81224
65	81291	81358	81425	81491	81558	81624	81690	81757	81823	81889
66	81954	82020	82086	82151	82217	82282	82347	82413	82478	82543
67	82607	82672	82737	82802	82866	82930	82995	83059	83123	83187
68	83251	83315	83378	83442	83506	83569	83632	83696	83759	83822
69	83885	83948	84011	84073	84136	84198	84261	84323	84386	84448
70	84510	84572	84634	84696	84757	84819	84880	84942	85003	85065
71	85126	85187	85248	85309	85370	85431	85491	85552	85612	85673
72	85733	85794	85854	85914	85974	86034	86094	86153	86213	86273
73	86332	86392	86451	86510	86570	86629	86688	86747	86806	86864
74	86923	86982	87040	87099	87157	87216	87274	87332	87390	87448
75	87506	87564	87622	87679	87737	87795	87852	87910	87967	88024
76	88081	88138	88195	88252	88309	88366	88423	88480	88536	88593
77	88649	88705	88762	88818	88874	88930	88986	89042	89098	89154
78	89209	89265	89321	89376	89432	89487	89542	89597	89653	89708
79	89763	89818	89873	89927	89982	90037	90091	90146	90200	90255
80	90309	90363	90417	90472	90526	90580	90634	90687	90741	90795
81	90849	90902	90956	91009	91062	91116	91169	91222	91275	91328
82	91381	91434	91487	91540	91593	91645	91698	91751	91803	91855
83	91908	91960	92012	92065	92117	92169	92221	92273	92324	92376
84	92428	92480	92531	92583	92634	92686	92737	92788	92840	92891
85	92942	92993	93044	93095	93146	93197	93247	93298	93349	93399
86	93450	93500	93551	93601	93651	93701	93752	93802	93852	93902
87	93952	94002	94052	94101	94151	94201	94250	94300	94349	94399
88	94448	94498	94547	94596	94645	94694	94743	94792	94841	94890
89	94939	94988	95036	95085	95134	95182	95231	95279	95328	95376
90	95424	95472	95521	95569	95617	95665	95713	95761	95809	95856
91	95904	95952	95999	96047	96095	96142	96190	96237	96284	96332
92	96379	96426	96473	96520	96567	96614	96661	96708	96755	96802
93	96848	96895	96942	96988	97035	97081	97128	97174	97220	97267
94	97313	97359	97405	97451	97497	97543	97589	97635	97681	97727
95	97772	97818	97864	97909	97955	98000	98046	98091	98137	98182
96	98227	98272	98318	98363	98408	98453	98498	98543	98588	98632
97	98677	98722	98767	98811	98856	98900	98945	98989	99034	99078
98	99123	99167	99211	99255	99300	99344	99388	99432	99476	99520
99	99564	99607	99651	99695	99739	99782	99826	99870	99913	99957
	0	1	2	3	4	5	6	7	8	9

31. Common Logarithms

LOG SINE

Angle	0'	10'	20'	30'	40'	50'	60'	
0°	— ∞	3.46373	3.76475	3.94084	2.06578	2.16268	2.24186	89
1	2.24186	2.30879	2.36678	2.41792	2.46366	2.50504	2.54282	88
2	2.54282	2.57757	2.60973	2.63968	2.66769	2.69400	2.71880	87
3	2.71880	2.74226	2.76451	2.78568	2.80585	2.82513	2.84358	86
4	2.84358	2.86128	2.87829	2.89464	2.91040	2.92561	2.94030	85°
5°	2.94030	2.95450	2.96825	2.98157	2.99450	1.00704	1.01923	84
6	1.01923	1.03109	1.04262	1.05386	1.06481	1.07548	1.08589	83
7	1.08589	1.09606	1.10599	1.11570	1.12519	1.13447	1.14356	82
8	1.14356	1.15245	1.16116	1.16970	1.17807	1.18628	1.19433	81
9	1.19433	1.20223	1.20999	1.21761	1.22509	1.23244	1.23967	80°
10°	1.23967	1.24677	1.25376	1.26063	1.26739	1.27405	1.28060	79
11	1.28060	1.28705	1.29340	1.29966	1.30582	1.31189	1.31788	78
12	1.31788	1.32378	1.32960	1.33534	1.34100	1.34658	1.35209	77
13	1.35209	1.35752	1.36289	1.36819	1.37341	1.37858	1.38368	76
14	1.38368	1.38871	1.39369	1.39860	1.40346	1.40825	1.41300	75°
15°	1.41300	1.41768	1.42232	1.42690	1.43143	1.43591	1.44034	74
16	1.44034	1.44472	1.44905	1.45334	1.45758	1.46178	1.46594	73
17	1.46594	1.47005	1.47411	1.47814	1.48213	1.48607	1.48998	72
18	1.48998	1.49385	1.49768	1.50148	1.50523	1.50896	1.51264	71
19	1.51264	1.51629	1.51991	1.52350	1.52705	1.53056	1.53405	70°
20°	1.53405	1.53751	1.54093	1.54433	1.54769	1.55102	1.55433	69
21	1.55433	1.55761	1.56085	1.56408	1.56727	1.57044	1.57358	68
22	1.57358	1.57669	1.57978	1.58284	1.58588	1.58889	1.59188	67
23	1.59188	1.59484	1.59778	1.60070	1.60359	1.60646	1.60931	66
24	1.60931	1.61214	1.61494	1.61773	1.62049	1.62323	1.62595	65°
25°	1.62595	1.62865	1.63133	1.63398	1.63662	1.63924	1.64184	64
26	1.64184	1.64442	1.64698	1.64953	1.65205	1.65456	1.65705	63
27	1.65705	1.65952	1.66197	1.66441	1.66682	1.66922	1.67161	62
28	1.67161	1.67398	1.67633	1.67866	1.68098	1.68328	1.68557	61
29	1.68557	1.68784	1.69010	1.69234	1.69456	1.69677	1.69897	60°
30°	1.69897	1.70115	1.70332	1.70547	1.70761	1.70973	1.71184	59
31	1.71184	1.71393	1.71602	1.71809	1.72014	1.72218	1.72421	58
32	1.72421	1.72622	1.72823	1.73022	1.73219	1.73416	1.73611	57
33	1.73611	1.73805	1.73997	1.74189	1.74379	1.74568	1.74756	56
34	1.74756	1.74943	1.75128	1.75313	1.75496	1.75678	1.75859	55°
35°	1.75859	1.76039	1.76218	1.76395	1.76572	1.76747	1.76922	54
36	1.76922	1.77095	1.77268	1.77439	1.77609	1.77778	1.77946	53
37	1.77946	1.78113	1.78280	1.78445	1.78609	1.78772	1.78934	52
38	1.78934	1.79095	1.79256	1.79415	1.79573	1.79731	1.79887	51
39	1.79887	1.80043	1.80197	1.80351	1.80504	1.80656	1.80807	50°
40°	1.80807	1.80957	1.81106	1.81254	1.81402	1.81549	1.81694	49
41	1.81694	1.81839	1.81983	1.82126	1.82269	1.82410	1.82551	48
42	1.82551	1.82691	1.82830	1.82968	1.83106	1.83242	1.83378	47
43	1.83378	1.83513	1.83648	1.83781	1.83914	1.84046	1.84177	46
44	1.84177	1.84308	1.84437	1.84566	1.84694	1.84822	1.84949	45°
	60'	50'	40'	30'	20'	10'	0'	Angle

LOG COSINE

of Sines and Cosines

LOG SINE

Angle	0'	10'	20'	30'	40'	50'	60'	
45°	ī.84949	ī.85074	ī.85200	ī.85324	ī.85448	ī.85571	ī.85693	44
46	ī.85693	ī.85815	ī.85936	ī.86056	ī.86176	ī.86295	ī.86413	43
47	ī.86413	ī.86530	ī.86647	ī.86763	ī.86879	ī.86993	ī.87107	42
48	ī.87107	ī.87221	ī.87334	ī.87446	ī.87557	ī.87668	ī.87778	41
49	ī.87778	ī.87887	ī.87996	ī.88105	ī.88212	ī.88319	ī.88425	40°
50°	ī.88425	ī.88531	ī.88636	ī.88741	ī.88844	ī.88948	ī.89050	39
51	ī.89050	ī.89152	ī.89254	ī.89354	ī.89455	ī.89554	ī.89653	38
52	ī.89653	ī.89752	ī.89849	ī.89947	ī.90043	ī.90139	ī.90235	37
53	ī.90235	ī.90330	ī.90424	ī.90518	ī.90611	ī.90704	ī.90796	36
54	ī.90796	ī.90887	ī.90978	ī.91069	ī.91158	ī.91248	ī.91336	35°
55°	ī.91336	ī.91425	ī.91512	ī.91599	ī.91686	ī.91772	ī.91857	34
56	ī.91857	ī.91942	ī.92027	ī.92111	ī.92194	ī.92277	ī.92359	33
57	ī.92359	ī.92441	ī.92522	ī.92603	ī.92683	ī.92763	ī.92842	32
58	ī.92842	ī.92921	ī.92999	ī.93077	ī.93154	ī.93230	ī.93307	31
59	ī.93307	ī.93382	ī.93457	ī.93532	ī.93606	ī.93680	ī.93753	30°
60°	ī.93753	ī.93826	ī.93898	ī.93970	ī.94041	ī.94112	ī.94182	29
61	ī.94182	ī.94252	ī.94321	ī.94390	ī.94458	ī.94526	ī.94593	28
62	ī.94593	ī.94660	ī.94727	ī.94793	ī.94858	ī.94923	ī.94988	27
63	ī.94988	ī.95052	ī.95116	ī.95179	ī.95242	ī.95304	ī.95366	26
64	ī.95366	ī.95427	ī.95488	ī.95549	ī.95609	ī.95668	ī.95728	25°
65°	ī.95728	ī.95786	ī.95844	ī.95902	ī.95960	ī.96017	ī.96073	24
66	ī.96073	ī.96129	ī.96185	ī.96240	ī.96294	ī.96349	ī.96403	23
67	ī.96403	ī.96456	ī.96509	ī.96562	ī.96614	ī.96665	ī.96717	22
68	ī.96717	ī.96767	ī.96818	ī.96868	ī.96917	ī.96966	ī.97015	21
69	ī.97015	ī.97063	ī.97111	ī.97159	ī.97206	ī.97252	ī.97299	20°
70°	ī.97299	ī.97344	ī.97390	ī.97435	ī.97479	ī.97523	ī.97567	19
71	ī.97567	ī.97610	ī.97653	ī.97696	ī.97738	ī.97779	ī.97821	18
72	ī.97821	ī.97861	ī.97902	ī.97942	ī.97982	ī.98021	ī.98060	17
73	ī.98060	ī.98098	ī.98136	ī.98174	ī.98211	ī.98248	ī.98284	16
74	ī.98284	ī.98320	ī.98356	ī.98391	ī.98426	ī.98460	ī.98494	15°
75°	ī.98494	ī.98528	ī.98561	ī.98594	ī.98627	ī.98659	ī.98690	14
76	ī.98690	ī.98722	ī.98753	ī.98783	ī.98813	ī.98843	ī.98872	13
77	ī.98872	ī.98901	ī.98930	ī.98958	ī.98986	ī.99013	ī.99040	12
78	ī.99040	ī.99067	ī.99093	ī.99119	ī.99145	ī.99170	ī.99195	11
79	ī.99195	ī.99219	ī.99243	ī.99267	ī.99290	ī.99313	ī.99335	10°
80°	ī.99335	ī.99357	ī.99379	ī.99400	ī.99421	ī.99442	ī.99462	9
81	ī.99462	ī.99482	ī.99501	ī.99520	ī.99539	ī.99557	ī.99575	8
82	ī.99575	ī.99593	ī.99610	ī.99627	ī.99643	ī.99659	ī.99675	7
83	ī.99675	ī.99690	ī.99705	ī.99720	ī.99734	ī.99748	ī.99761	6
84	ī.99761	ī.99775	ī.99787	ī.99800	ī.99812	ī.99823	ī.99834	5°
85°	ī.99834	ī.99845	ī.99856	ī.99866	ī.99876	ī.99885	ī.99894	4
86	ī.99894	ī.99903	ī.99911	ī.99919	ī.99926	ī.99934	ī.99940	3
87	ī.99940	ī.99947	ī.99953	ī.99959	ī.99964	ī.99969	ī.99974	2
88	ī.99974	ī.99978	ī.99982	ī.99985	ī.99988	ī.99991	ī.99993	1
89	ī.99993	ī.99995	ī.99997	ī.99998	ī.99999	o.00000	o.00000	0°
	60'	50'	40'	30'	20'	10'	0'	Angle

LOG COSINE

LOG TANGENT

Angle	0'	10'	20'	30'	40'	50'	60'	
0°	— ∞	3.46373	3.76476	3.94086	2.06581	2.16273	2.24192	89
1	2.24192	2.30888	2.36689	2.41807	2.46385	2.50527	2.54308	88
2	2.54308	2.57788	2.61009	2.64009	2.66816	2.69453	2.71940	87
3	2.71940	2.74292	2.76525	2.78649	2.80674	2.82610	2.84464	86
4	2.84464	2.86243	2.87953	2.89598	2.91185	2.92716	2.94195	85°
5°	2.94195	2.95627	2.97013	2.98358	2.99662	1.00930	1.02162	84
6	1.02162	1.03361	1.04528	1.05666	1.06775	1.07858	1.08914	83
7	1.08914	1.09947	1.10956	1.11943	1.12909	1.13854	1.14780	82
8	1.14780	1.15688	1.16577	1.17450	1.18306	1.19146	1.19971	81
9	1.19971	1.20782	1.21578	1.22361	1.23130	1.23887	1.24632	80°
10°	1.24632	1.25365	1.26086	1.26797	1.27496	1.28186	1.28865	79
11	1.28865	1.29535	1.30195	1.30846	1.31489	1.32122	1.32747	78
12	1.32747	1.33365	1.33974	1.34576	1.35170	1.35757	1.36336	77
13	1.36336	1.36909	1.37476	1.38035	1.38589	1.39136	1.39677	76
14	1.39677	1.40212	1.40742	1.41266	1.41784	1.42297	1.42805	75°
15°	1.42805	1.43308	1.43806	1.44299	1.44787	1.45271	1.45750	74
16	1.45750	1.46224	1.46694	1.47160	1.47622	1.48080	1.48534	73
17	1.48534	1.48984	1.49430	1.49872	1.50311	1.50746	1.51178	72
18	1.51178	1.51606	1.52031	1.52452	1.52870	1.53285	1.53697	71
19	1.53697	1.54106	1.54512	1.54915	1.55315	1.55712	1.56107	70°
20°	1.56107	1.56498	1.56887	1.57274	1.57658	1.58039	1.58418	69
21	1.58418	1.58794	1.59168	1.59540	1.59909	1.60276	1.60641	68
22	1.60641	1.61004	1.61364	1.61722	1.62079	1.62433	1.62785	67
23	1.62785	1.63135	1.63484	1.63830	1.64175	1.64517	1.64858	66
24	1.64858	1.65197	1.65535	1.65870	1.66204	1.66537	1.66867	65°
25°	1.66867	1.67196	1.67524	1.67850	1.68174	1.68497	1.68818	64
26	1.68818	1.69138	1.69457	1.69774	1.70089	1.70404	1.70717	63
27	1.70717	1.71028	1.71339	1.71648	1.71955	1.72262	1.72567	62
28	1.72567	1.72872	1.73175	1.73476	1.73777	1.74077	1.74375	61
29	1.74375	1.74673	1.74969	1.75264	1.75558	1.75852	1.76144	60°
30°	1.76144	1.76435	1.76725	1.77015	1.77303	1.77591	1.77877	59
31	1.77877	1.78163	1.78448	1.78732	1.79015	1.79297	1.79579	58
32	1.79579	1.79860	1.80140	1.80419	1.80697	1.80975	1.81252	57
33	1.81252	1.81528	1.81803	1.82078	1.82352	1.82626	1.82899	56
34	1.82899	1.83171	1.83442	1.83713	1.83984	1.84254	1.84523	55°
35°	1.84523	1.84791	1.85059	1.85327	1.85594	1.85860	1.86126	54
36	1.86126	1.86392	1.86656	1.86921	1.87185	1.87448	1.87711	53
37	1.87711	1.87974	1.88236	1.88498	1.88759	1.89020	1.89281	52
38	1.89281	1.89541	1.89801	1.90061	1.90320	1.90578	1.90837	51
39	1.90837	1.91095	1.91353	1.91610	1.91868	1.92125	1.92381	50°
40°	1.92381	1.92638	1.92894	1.93150	1.93406	1.93661	1.93916	49
41	1.93916	1.94171	1.94426	1.94681	1.94935	1.95190	1.95444	48
42	1.95444	1.95698	1.95952	1.96205	1.96459	1.96712	1.96966	47
43	1.96966	1.97219	1.97472	1.97725	1.97978	1.98231	1.98484	46
44	1.98484	1.98737	1.98989	1.99242	1.99495	1.99747	0.00000	45°
	60'	50'	40'	30'	20'	10'	0'	Angle

LOG COTANGENT

of Tangents and Cotangents

LOG TANGENT

Angle	0'	10'	20'	30'	40'	50'	60'	
45°	0.00000	0.00253	0.00505	0.00758	0.01011	0.01263	0.01516	44
46	0.01516	0.01769	0.02022	0.02275	0.02528	0.02781	0.03034	43
47	0.03034	0.03288	0.03541	0.03795	0.04048	0.04302	0.04556	42
48	0.04556	0.04810	0.05065	0.05319	0.05574	0.05829	0.06084	41
49	0.06084	0.06339	0.06594	0.06850	0.07106	0.07362	0.07619	40°
50°	0.07619	0.07875	0.08132	0.08390	0.08647	0.08905	0.09163	39
51	0.09163	0.09422	0.09680	0.09939	0.10199	0.10459	0.10719	38
52	0.10719	0.10980	0.11241	0.11502	0.11764	0.12026	0.12289	37
53	0.12289	0.12552	0.12815	0.13079	0.13344	0.13608	0.13874	36
54	0.13874	0.14140	0.14406	0.14673	0.14941	0.15209	0.15477	35°
55°	0.15477	0.15746	0.16016	0.16287	0.16558	0.16829	0.17101	34
56	0.17101	0.17374	0.17648	0.17922	0.18197	0.18472	0.18748	33
57	0.18748	0.19025	0.19303	0.19581	0.19860	0.20140	0.20421	32
58	0.20421	0.20703	0.20985	0.21268	0.21552	0.21837	0.22123	31
59	0.22123	0.22409	0.22697	0.22985	0.23275	0.23565	0.23856	30°
60°	0.23856	0.24148	0.24442	0.24736	0.25031	0.25327	0.25625	29
61	0.25625	0.25923	0.26223	0.26524	0.26825	0.27128	0.27433	28
62	0.27433	0.27738	0.28045	0.28352	0.28661	0.28972	0.29283	27
63	0.29283	0.29596	0.29911	0.30226	0.30543	0.30862	0.31182	26
64	0.31182	0.31503	0.31826	0.32150	0.32476	0.32804	0.33133	25°
65°	0.33133	0.33463	0.33796	0.34130	0.34465	0.34803	0.35142	24
66	0.35142	0.35483	0.35825	0.36170	0.36516	0.36865	0.37215	23
67	0.37215	0.37567	0.37921	0.38278	0.38636	0.38996	0.39359	22
68	0.39359	0.39724	0.40091	0.40460	0.40832	0.41206	0.41582	21
69	0.41582	0.41961	0.42342	0.42726	0.43113	0.43502	0.43893	20°
70°	0.43893	0.44288	0.44685	0.45085	0.45488	0.45894	0.46303	19
71	0.46303	0.46715	0.47130	0.47548	0.47969	0.48394	0.48822	18
72	0.48822	0.49254	0.49689	0.50128	0.50570	0.51016	0.51466	17
73	0.51466	0.51920	0.52378	0.52840	0.53306	0.53776	0.54250	16
74	0.54250	0.54729	0.55213	0.55701	0.56194	0.56692	0.57195	15°
75°	0.57195	0.57703	0.58216	0.58734	0.59258	0.59788	0.60323	14
76	0.60323	0.60864	0.61411	0.61965	0.62524	0.63091	0.63664	13
77	0.63664	0.64243	0.64830	0.65424	0.66026	0.66635	0.67253	12
78	0.67253	0.67878	0.68511	0.69154	0.69805	0.70465	0.71135	11
79	0.71135	0.71814	0.72504	0.73203	0.73914	0.74635	0.75368	10°
80°	0.75368	0.76113	0.76870	0.77639	0.78422	0.79218	0.80029	9
81	0.80029	0.80854	0.81694	0.82550	0.83423	0.84312	0.85220	8
82	0.85220	0.86146	0.87091	0.88057	0.89044	0.90053	0.91086	7
83	0.91086	0.92142	0.93225	0.94334	0.95472	0.96639	0.97838	6
84	0.97838	0.99070	1.00338	1.01642	1.02987	1.04373	1.05805	5°
85°	1.05805	1.07284	1.08815	1.10402	1.12047	1.13757	1.15536	4
86	1.15536	1.17390	1.19326	1.21351	1.23475	1.25708	1.28060	3
87	1.28060	1.30547	1.33184	1.35991	1.38991	1.42212	1.45692	2
88	1.45692	1.49473	1.53615	1.58193	1.63311	1.69112	1.75808	1
89	1.75808	1.83727	1.93419	2.05914	2.23524	2.53627	∞	0°
	60'	50'	40'	30'	20'	10'	0'	Angle

LOG COTANGENT

33. Logarithms of Trigonometric Functions

Angle	Log Arc	Log Sin	Log Tan	Log Sec	Log Csc	Log Cot	Log Cos		
1°	2.2419	2.2419	2.2419	0.0001	1.7581	1.7581	1.9999	0.1913	89
2	2.5429	2.5428	2.5431	0.0003	1.4572	1.4569	1.9997	0.1864	88
3	2.7190	2.7188	2.7194	0.0006	1.2812	1.2806	1.9994	0.1814	87
4	2.8439	2.8436	2.8446	0.0011	1.1564	1.1554	1.9989	0.1764	86
5	2.9408	2.9403	2.9420	0.0017	1.0597	1.0580	1.9983	0.1713	85°
6°	1.0200	1.0192	1.0216	0.0024	0.9808	0.9784	1.9976	0.1662	84
7	1.0870	1.0859	1.0891	0.0032	0.9141	0.9109	1.9968	0.1610	83
8	1.1450	1.1436	1.1478	0.0042	0.8564	0.8522	1.9958	0.1557	82
9	1.1961	1.1943	1.1997	0.0054	0.8057	0.8003	1.9946	0.1504	81
10	1.2419	1.2397	1.2463	0.0066	0.7603	0.7537	1.9934	0.1450	80°
11°	1.2833	1.2806	1.2887	0.0081	0.7194	0.7113	1.9919	0.1395	79
12	1.3211	1.3179	1.3275	0.0096	0.6821	0.6725	1.9904	0.1340	78
13	1.3558	1.3521	1.3634	0.0113	0.6479	0.6366	1.9887	0.1284	77
14	1.3880	1.3837	1.3968	0.0131	0.6163	0.6032	1.9869	0.1227	76
15	1.4180	1.4130	1.4281	0.0151	0.5870	0.5719	1.9849	0.1169	75°
16°	1.4460	1.4403	1.4575	0.0172	0.5597	0.5425	1.9828	0.1111	74
17	1.4723	1.4659	1.4853	0.0194	0.5341	0.5147	1.9806	0.1052	73
18	1.4971	1.4900	1.5118	0.0218	0.5100	0.4882	1.9782	0.0992	72
19	1.5206	1.5126	1.5370	0.0243	0.4874	0.4630	1.9757	0.0931	71
20	1.5429	1.5341	1.5611	0.0270	0.4659	0.4389	1.9730	0.0870	70°
21°	1.5641	1.5543	1.5842	0.0298	0.4457	0.4158	1.9702	0.0807	69
22	1.5843	1.5736	1.6064	0.0328	0.4264	0.3936	1.9672	0.0744	68
23	1.6036	1.5919	1.6279	0.0360	0.4081	0.3721	1.9640	0.0680	67
24	1.6221	1.6093	1.6486	0.0393	0.3907	0.3514	1.9607	0.0614	66
25	1.6398	1.6259	1.6687	0.0427	0.3741	0.3313	1.9573	0.0548	65°
26°	1.6569	1.6418	1.6882	0.0463	0.3582	0.3118	1.9537	0.0481	64
27	1.6732	1.6570	1.7072	0.0501	0.3430	0.2928	1.9499	0.0412	63
28	1.6890	1.6716	1.7257	0.0541	0.3284	0.2743	1.9459	0.0343	62
29	1.7042	1.6856	1.7438	0.0582	0.3144	0.2562	1.9418	0.0272	61
30	1.7190	1.6990	1.7614	0.0625	0.3010	0.2386	1.9375	0.0200	60°
31°	1.7332	1.7118	1.7788	0.0669	0.2882	0.2212	1.9331	0.0127	59
32	1.7470	1.7242	1.7958	0.0716	0.2758	0.2042	1.9284	0.0053	58
33	1.7604	1.7361	1.8125	0.0764	0.2639	0.1875	1.9236	1.9978	57
34	1.7734	1.7476	1.8290	0.0814	0.2524	0.1710	1.9186	1.9901	56
35	1.7859	1.7586	1.8452	0.0866	0.2414	0.1548	1.9134	1.9822	55°
36°	1.7982	1.7692	1.8613	0.0920	0.2308	0.1387	1.9080	1.9743	54
37	1.8101	1.7795	1.8771	0.0977	0.2205	0.1229	1.9023	1.9662	53
38	1.8217	1.7893	1.8928	0.1035	0.2107	0.1072	1.8965	1.9579	52
39	1.8329	1.7989	1.9084	0.1095	0.2011	0.0916	1.8905	1.9494	51
40	1.8439	1.8081	1.9238	0.1157	0.1919	0.0762	1.8843	1.9408	50°
41°	1.8547	1.8169	1.9392	0.1222	0.1831	0.0608	1.8778	1.9321	49
42	1.8651	1.8255	1.9544	0.1289	0.1745	0.0456	1.8711	1.9231	48
43	1.8753	1.8338	1.9697	0.1359	0.1662	0.0303	1.8641	1.9140	47
44	1.8853	1.8418	1.9848	0.1431	0.1582	0.0152	1.8569	1.9046	46
45	1.8951	1.8495	0.0000	0.1505	0.1505	0.0000	1.8495	1.8951	45°
		Log Cos	Log Cot	Log Csc	Log Sec	Log Tan	Log Sin	Log Arc	Angle

34. Explanations

Table 30 gives five-place Logarithms of three-place numbers. The word logarithm and its abbreviation log, when used without qualification, refer to a common logarithm which is defined by the equation $10^{\log n} = n$. The table gives the decimal part, or mantissa, of a logarithm, while the integral part, or characteristic, is to be supplied by the following rules: When the number is greater than 1, the characteristic of its log is positive and is one less than the number of figures preceding the decimal point; thus,

$$\log 6.54 = 0.81558 \quad \log 65.4 = 1.81558 \quad \log 654 = 2.81558$$

When the number is less than 1, the characteristic of its log is negative and is numerically one greater than the number of ciphers immediately following the decimal point, thus the four-place log of 6 is 0.7782, and

$$\log 0.6 = \bar{1}.7782 \quad \log 0.06 = \bar{2}.7782 \quad \log 0.006 = \bar{3}.7782$$

Here the characteristic is negative and the mantissa is positive, so that $\bar{2}.7782$ is the same as $-2 + 0.7782$. When the given number is an integral power of 10, the mantissa is zero, so that $\log 1000 = 3$, $\log 0.1 = -1$, $\log 0.01 = -2$, and $\log 1 = 0$.

Multiplication and Division may be performed by the help of logarithms and the use of the following rules:

$$\begin{array}{ll} \text{To multiply } a \text{ by } b, & \log a + \log b = \log ab \\ \text{To divide } a \text{ by } b, & \log a - \log b = \log a/b \end{array}$$

Here $\log a$ and $\log b$ are obtained from Table 30 and the above rules for the characteristic; then the numbers corresponding to $\log ab$ and $\log a/b$ are found from the Table. For example, to multiply 68.31 by 0.2754, the sum of the logs is 1.27444 and its corresponding number is 18.812, the last decimal being in error.

Roots and Powers of numbers are most conveniently computed by logarithms and the use of the following rules:

$$\text{To extract the } n\text{th root of } a, \quad \frac{1}{n} \log a = \log a^{\frac{1}{n}}$$

$$\text{To raise } a \text{ to the } m\text{th power,} \quad m \log a = \log a^m$$

For example, to raise 0.6831 to the 1.53 power: $1.53 \times \bar{1}.83448$

33. Logarithms of Trigonometric Functions

Angle	Log Arc	Log Sin	Log Tan	Log Sec	Log Csc	Log Cot	Log Cos		
1°	2.2419	2.2419	2.2419	0.0001	1.7581	1.7581	1.9999	0.1913	89
2	2.5429	2.5428	2.5431	0.0003	1.4572	1.4569	1.9997	0.1864	88
3	2.7190	2.7188	2.7194	0.0006	1.2812	1.2806	1.9994	0.1814	87
4	2.8439	2.8436	2.8446	0.0011	1.1564	1.1554	1.9989	0.1764	86
5	2.9408	2.9403	2.9420	0.0017	1.0597	1.0580	1.9983	0.1713	85°
6°	1.0200	1.0192	1.0216	0.0024	0.9808	0.9784	1.9976	0.1662	84
7	1.0870	1.0859	1.0891	0.0032	0.9141	0.9109	1.9968	0.1610	83
8	1.1450	1.1436	1.1478	0.0042	0.8564	0.8522	1.9958	0.1557	82
9	1.1961	1.1943	1.1997	0.0054	0.8057	0.8003	1.9946	0.1504	81
10	1.2419	1.2397	1.2463	0.0066	0.7603	0.7537	1.9934	0.1450	80°
11°	1.2833	1.2806	1.2887	0.0081	0.7194	0.7113	1.9919	0.1395	79
12	1.3211	1.3179	1.3275	0.0096	0.6821	0.6725	1.9904	0.1340	78
13	1.3558	1.3521	1.3634	0.0113	0.6479	0.6366	1.9887	0.1284	77
14	1.3880	1.3837	1.3968	0.0131	0.6163	0.6032	1.9869	0.1227	76
15	1.4180	1.4130	1.4281	0.0151	0.5870	0.5719	1.9849	0.1169	75°
16°	1.4460	1.4403	1.4575	0.0172	0.5597	0.5425	1.9828	0.1111	74
17	1.4723	1.4659	1.4853	0.0194	0.5341	0.5147	1.9806	0.1052	73
18	1.4971	1.4900	1.5118	0.0218	0.5100	0.4882	1.9782	0.0992	72
19	1.5206	1.5126	1.5370	0.0243	0.4874	0.4630	1.9757	0.0931	71
20	1.5429	1.5341	1.5611	0.0270	0.4659	0.4389	1.9730	0.0870	70°
21°	1.5641	1.5543	1.5842	0.0298	0.4457	0.4158	1.9702	0.0807	69
22	1.5843	1.5736	1.6064	0.0328	0.4264	0.3936	1.9672	0.0744	68
23	1.6036	1.5919	1.6279	0.0360	0.4081	0.3721	1.9640	0.0680	67
24	1.6221	1.6093	1.6486	0.0393	0.3907	0.3514	1.9607	0.0614	66
25	1.6398	1.6259	1.6687	0.0427	0.3741	0.3313	1.9573	0.0548	65°
26°	1.6569	1.6418	1.6882	0.0463	0.3582	0.3118	1.9537	0.0481	64
27	1.6732	1.6570	1.7072	0.0501	0.3430	0.2928	1.9499	0.0412	63
28	1.6890	1.6716	1.7257	0.0541	0.3284	0.2743	1.9459	0.0343	62
29	1.7042	1.6856	1.7438	0.0582	0.3144	0.2562	1.9418	0.0272	61
30	1.7190	1.6990	1.7614	0.0625	0.3010	0.2386	1.9375	0.0200	60°
31°	1.7332	1.7118	1.7788	0.0669	0.2882	0.2212	1.9331	0.0127	59
32	1.7470	1.7242	1.7958	0.0716	0.2758	0.2042	1.9284	0.0053	58
33	1.7604	1.7361	1.8125	0.0764	0.2639	0.1875	1.9236	1.9978	57
34	1.7734	1.7476	1.8290	0.0814	0.2524	0.1710	1.9186	1.9901	56
35	1.7859	1.7586	1.8452	0.0866	0.2414	0.1548	1.9134	1.9822	55°
36°	1.7982	1.7692	1.8613	0.0920	0.2308	0.1387	1.9080	1.9743	54
37	1.8101	1.7795	1.8771	0.0977	0.2205	0.1229	1.9023	1.9662	53
38	1.8217	1.7893	1.8928	0.1035	0.2107	0.1072	1.8965	1.9579	52
39	1.8329	1.7989	1.9084	0.1095	0.2011	0.0916	1.8905	1.9494	51
40	1.8439	1.8081	1.9238	0.1157	0.1919	0.0762	1.8843	1.9408	50°
41°	1.8547	1.8169	1.9392	0.1222	0.1831	0.0608	1.8778	1.9321	49
42	1.8651	1.8255	1.9544	0.1289	0.1745	0.0456	1.8711	1.9231	48
43	1.8753	1.8338	1.9697	0.1359	0.1662	0.0303	1.8641	1.9140	47
44	1.8853	1.8418	1.9848	0.1431	0.1582	0.0152	1.8569	1.9046	46
45	1.8951	1.8495	0.0000	0.1505	0.1505	0.0000	1.8495	1.8951	45°
		Log Cos	Log Cot	Log Csc	Log Sec	Log Tan	Log Sin	Log Arc	Angle

34. Explanations

Table 30 gives five-place Logarithms of three-place numbers. The word logarithm and its abbreviation log, when used without qualification, refer to a common logarithm which is defined by the equation $10^{\log n} = n$. The table gives the decimal part, or mantissa, of a logarithm, while the integral part, or characteristic, is to be supplied by the following rules: When the number is greater than 1, the characteristic of its log is positive and is one less than the number of figures preceding the decimal point; thus,

$$\log 6.54 = 0.81558 \quad \log 65.4 = 1.81558 \quad \log 654 = 2.81558$$

When the number is less than 1, the characteristic of its log is negative and is numerically one greater than the number of ciphers immediately following the decimal point, thus the four-place log of 6 is 0.7782, and

$$\log 0.6 = \bar{1}.7782 \quad \log 0.06 = \bar{2}.7782 \quad \log 0.006 = \bar{3}.7782$$

Here the characteristic is negative and the mantissa is positive, so that $\bar{2}.7782$ is the same as $-2 + 0.7782$. When the given number is an integral power of 10, the mantissa is zero, so that $\log 1000 = 3$, $\log 0.1 = -1$, $\log 0.01 = -2$, and $\log 1 = 0$.

Multiplication and Division may be performed by the help of logarithms and the use of the following rules:

$$\begin{array}{ll} \text{To multiply } a \text{ by } b, & \log a + \log b = \log ab \\ \text{To divide } a \text{ by } b, & \log a - \log b = \log a/b \end{array}$$

Here $\log a$ and $\log b$ are obtained from Table 30 and the above rules for the characteristic; then the numbers corresponding to $\log ab$ and $\log a/b$ are found from the Table. For example, to multiply 68.31 by 0.2754, the sum of the logs is 1.27444 and its corresponding number is 18.812, the last decimal being in error.

Roots and Powers of numbers are most conveniently computed by logarithms and the use of the following rules:

$$\text{To extract the } n\text{th root of } a, \quad \frac{1}{n} \log a = \log a^{\frac{1}{n}}$$

$$\text{To raise } a \text{ to the } m\text{th power,} \quad m \log a = \log a^m$$

For example, to raise 0.6831 to the 1.53 power: $1.53 \times \bar{1}.83448$

$= -1.53 + 1.27675 = \bar{2}.47 + 1.27675 = \bar{1}.74675$, which is \log of 0.55815. To find the fifth root of 0.6831: one-fifth of $\bar{1}.83448$ is $\frac{1}{5} (-5 + 4.83448) = \bar{1}.96690$, which is \log of 0.9262; or it is perhaps better to multiply by 0.2 instead of dividing by 5, thus $0.2 (\bar{1}.83448) = 0.2 (-1 + 0.83448) = -0.2 + 0.16690 = -1 + 0.8 + 0.16690 = \bar{1}.96690$.

Tables 31 and 32 give logarithms of trigonometric functions to five decimal places at intervals of $10'$, the characteristics being given. For $\log \sin$ and $\log \tan$ look for the degree at the left-hand side and for the minutes at the top; for $\log \cos$ and $\log \cot$ look for the degree at the right-hand side and for the minutes at the foot. In many books these functions are called logarithmic sines, logarithmic tangents, etc., while the characteristics are written 8 and 9 instead of $\bar{2}$ and $\bar{1}$, thus requiring some power of 10 to be subtracted later. Here the final logarithm of a computation is correct without such subtraction.

Table 33 gives four-place logarithms of trigonometric functions, and its arrangement is the same as that of Table 29.

35. Exercises

1. Find the logarithms of 7.25, 7250, and 0.725.
2. Find the numbers whose logarithms are 1.64933, 6.64933, $\bar{2}.64933$, 0.70520, $\bar{1}.70520$, and 0.73998.
3. Compute by logarithms the sixth powers of 3.25 and 0.325; also the sixth roots of 3.27 and 0.327.
4. Using logarithms, multiply 32.16 by 0.01555; also divide 1825 by 0.03245.
5. Find \log sines of $44^\circ 22'$ and $44^\circ 25'$; also \log cosines and tangents of the same angles.
6. Given $a = b \sin A / \sin B$ compute the value of a when $b = 973$ feet, $A = 24^\circ 40'$, and $B = 73^\circ 10'$.
7. Compute the value of $0.375 \tan 85^\circ$; also of $\sec 78^\circ \times \cos 78^\circ$; also of $\cot 39^\circ 10' \times \sin 39^\circ 10' / \cos 39^\circ 10'$.
8. In a right-angled triangle the hypotenuse is 505 feet; compute the other two sides when one of the acute angles is $53^\circ 8'$.
9. When a vertical post 3.125 feet high casts a shadow 8.275 feet long on a level plane, what is the elevation of the sun above the horizon?

CHAPTER 6

WEIGHTS AND MEASURES

36. Length

1 meter = 10 decimeters = 100 centimeters = 1000 millimeters = 10^6 microns = 0.1 deka-meter = 0.01 hectometer = 0.001 kilometer = 0.0001 myriameter.

1 U. S. yard = 3600/3937 meters (by definition); $\log = \bar{1}.9611371$.

Meters	Inches	Feet	Yards	Links	Rods, poles, or perches	Chains, Gunter's	Statute miles U. S.	Nautical miles U. S.
1	39.37 1.59517*	3.2808 0.51598*	1.0936 0.03886*	4.971 0.69644*	0.1988 1.29850*	0.04971 2.69644*	0.(3)6214 4.79335*	0.(3)5396 4.73207*
0.0254 2.40483*	1 2.92082*	0.08333 2.44370*	0.02778 2.44370*	0.1263 1.10127*	0.005051 3.70333*	0.001263 3.10127*	0.(4)1578 3.19818*	0.(4)1371 3.13690*
0.3048 1.48402*	12 1.07918*	1 1.52288*	0.3333 1.52288*	1.515 0.18046*	0.06061 2.78252*	0.01515 2.18046*	0.(3)1894 4.27737*	0.(3)1615 4.21608*
0.9144 1.96114*	36 1.55630*	3 0.47712*	1 0.65758*	4.545 0.65758*	0.1818 1.25964*	0.04545 2.65758*	0.(3)5682 4.75449*	0.(3)4934 4.69320*
0.2012 1.30356*	7.92 0.89873*	0.66 1.81954*	0.22 1.34242*	1 1.39794*	0.04 2.60206*	0.01 2.00000*	0.(3)1250 4.09691*	0.(3)1086 4.03564*
5.029 0.70150*	198 2.29667*	16.5 1.21748*	5.5 0.74036*	25 1.39794*	1 1.39794*	0.25 3.49485*	0.(2)3125 3.43357*	0.(2)2714 3.43357*
20.12 1.30356*	792 2.89873*	66 1.81954*	22 1.34242*	100 2.00000*	4 0.60206*	1 2.00000*	0.0125 2.09691*	0.01086 2.03564*
1609.3 3.20665*	63360 4.80182*	5280 3.72263*	1760 3.24551*	8000 3.90309*	320 2.50515*	80 1.90309*	1 1.90309*	0.8684 1.93872*
1853.25 3.26793*	72962 4.86310*	6080.2 3.78392*	2026.73 3.30680*	9212 3.96437*	368.5 2.56643*	92.12 1.96437*	1.1516 0.06128*	1 0.06128*

1 nautical mile of the British admiralty = 6080 ft. 1 furlong = $\frac{1}{8}$ mile = 660 feet.
1 league = 3 miles = 24 furlongs. 1 fathom = 2 yards = 6 feet.

* Logarithm of the number immediately above.

37. Area

1 hectare = 100 ares = 10 000 centares or square meters.

Square meters	Square inches	Square feet	Square yards	Square rods	Square chains	Acres	Square miles or sections
1	1550 3.19033*	10.764 1.03197*	1.1960 0.07773*	0.03954 2.59700*	0.(2)2471 3.39288*	0.(3)2471 4.39288*	0.(6)3861 7.38670*
0.(3)5452 4.80967*	1 2.92082*	0.006944 3.84164*	0.(2)7716 3.88740*	0.(4)2551 5.40667*	0.(5)1594 6.20255*	0.(6)1594 7.20255*	0.(9)2491 10.39637*
0.09290 2.96803*	144 2.15836*	1 0.95424*	0.1111 1.04576*	0.(2)3673 3.50503*	0.(3)2296 4.36091*	0.(4)2296 5.36091*	0.(7)3587 8.55473*
0.8361 1.92227*	1296 3.11260*	9 0.95424*	1 0.03306	0.03306 2.51927*	0.(2)2066 3.31515*	0.(3)2066 4.31515*	0.(6)3228 7.50898*
25.29 1.40300*	39204 4.5933*	272.25 2.43497*	30.25 1.48072*	1 2.79588*	0.0625 3.79588*	0.00625 3.79588*	0.(5)9766 6.98970*
404.69 2.60712*	627264 5.79745*	4356 3.63909*	484 2.68484*	16 1.20412*	1 1.00000*	0.1 1.00000*	0.(3)1562 4.19382*
4046.9 3.60712*	6272640 6.79745*	43560 4.63909*	4840 3.68484*	160 2.20412*	10 1.00000*	1 1.00000*	0.001562 3.19382*
2589998 6.41330*		27878400 7.44527*	3097600 6.49102*	102400 5.01030*	6400 3.80618*	640 2.80618*	1 2.80618*

* Logarithm of the number immediately above.

38. Speed and Velocity

Cm per sec	Km per hour	Ft per sec	Ft per min	Miles per hour	Knots
1	0.036	0.03281	1.9685	0.02237	0.01942
	2.55630*	2.51598*	0.29413*	2.34965*	2.28825*
27.7778	1	0.91134	54.6806	0.62137	0.53960
1.44370*		1.95968*	1.73783*	1.79335*	1.73207*
30.4801	1.0973	1	60	0.68182	0.59209
1.48402*	0.04032*		1.77815*	1.83367*	1.77238*
0.5080	0.01829	0.01667	1	0.01136	0.009868
1.70586*	2.26217*	2.22185*		2.05553*	3.99423*
44.7041	1.6093	1.46667	88	1	0.86839
1.65035*	0.20670*	0.16633*	1.94448*		1.93872*
51.4971	1.8532	1.68894	101.337	1.15155	1
1.71178*	0.26793*	0.22761*	2.00577*	0.06128*	

1 knot = 1 nautical mile per hour.

* Logarithm of the number immediately above.

39. Volume and Capacity

1 liter = 1 cubic decimeter = 1000 cubic centimeters = 10 deciliters = 100 centiliters = 1000 milliliters = 0.1 dekaliter = 0.01 hectoliter = 0.01 kiloliter = 0.001 cubic meters or steres.

Cubic inches	Cubic feet	Cubic yards	U. S. quarts		Gallons		Bushels U. S.	Liters
			Liquid	Dry	U. S. liquid	U. S. dry		
1	0.00057870	0.0001357	0.017316	0.014881	0.004329	0.003720	0.0004650	0.016387
	7.6246*	3.33109*	2.23845*	2.17263*	3.63639*	3.57057*	4.66748*	2.21450*
1728	1	0.037037	29.922	25.714	7.4805	6.4285	0.80356	28.317
3.23754*		2.56864*	1.47599*	1.41017*	0.87393*	0.80811*	1.90502*	1.45205*
46656	27	1	807.90	694.28	201.97	173.57	21.696	764.56
4.66891*	1.43136*		2.90736*	2.84153*	2.30530*	2.23948*	1.33638*	2.88341*
57.75	0.033420	0.001238	1	0.85937	0.25	0.21484	0.026855	0.94636
1.76155*	2.52401*	3.09026*		1.93418*	1.39794*	1.33212*	2.42903*	1.97606*
67.201	0.038889	0.001440	1.1637	1	0.29091	0.25	0.03125	1.1012
1.82737*	2.58983*	3.15847*	0.06582*		1.46376*	1.39794*	2.49485*	0.04188*
231	0.13368	0.004951	4	3.4375	1	0.85937	0.10742	3.7854
2.36361*	1.12607*	3.69471*	0.60206*	0.53624*		1.93418*	1.03109*	0.57812*
268.80	0.15556	0.005761	4.6546	4	1.1637	1	0.125	4.4049
2.42943*	1.19189*	3.76053*	0.66788*	0.60201*	0.06582*		1.09691*	0.64394*
2150.4	1.2445	0.046091	37.237	32	9.3092	8	1	35.239
3.33253*	0.09498*	2.66362*	1.57097*	1.50515*	0.96891*	0.90309*		1.54703*
61.023	0.035315	0.001308	1.0567	0.90808	0.26417	0.22702	0.028377	1
1.78550*	2.54795*	3.11659*	0.02394*	1.95812*	1.42188*	1.35606*	2.45297*	

1 U. S. liquid quart = 2 pints = 8 gills = 32 fluid ounces = 256 fluid drams = 768 fluid scruples. 1 bushel = 4 pecks.

1 Imperial gallon = 1.201 U. S. gallons = 0.1605 cu ft = 4.5460 liters.

1 U. S. gallon = 0.8327 Imperial gallons. 1 cubic foot = 6.229 Imperial gallons.

1 British bushel = 1.2837 cubic feet.

Shipping Measure: 1 register ton = 100 cu ft. 1 U. S. shipping ton = 40 cu ft.
1 British shipping ton = 42 cu ft

* Logarithm of the number immediately above.

40. Weight (Engineers' System) or Mass (Physicists' System)

1 kilogram = 1000 grams = 0.001 metric ton. 1 gm = 10 decigrams = 100 centigrams = 1000 milligrams = 0.1 dekagram = 0.01 hectogram = 0.001 kilogram = 0.0001 myriagram.
 1 U. S. Avoirdupois pound = 0.4535924277 kg = (by definition) 7000/5760 troy pounds.

Kilo-grams	Grains	Ounces		Pounds		Tons		
		Avoir.	Troy and apoth.	Troy and apoth.	Avoir.	Short, 2000 lb	Long, 2240 lb	Metric, 1000 kg
1	15432.	35.274	32.151	2.6792	2.20461	0.001102	0.(3)9842	0.001
	4.18843*	1.54745*	1.50719*	0.42801*	0.34333*	3.04230*	4.99309*	3.00000*
0.(4)6480	1	0.(2)2286	0.002083	0.(3)1736	0.(3)142			
3.81157*		3.35902*	3.31876*	4.23958*	4.15490*			
0.028349	437.5	1	0.91146	0.075955	0.0625	0.(4)3125	0.(4)2790	0.(4)2835
2.45255*	2.64098*		1.95974*	2.88056*	2.79588*	3.49485*	3.44563*	3.45255*
0.031103	480	1.0971	1	0.083333	0.068571	0.(4)3429	0.(3)3061	0.(4)3110
2.49281*	2.68124*	0.04026*		2.92082*	2.83614*	3.53511*	4.56508*	3.49281*
0.37324	5760	13.166	12	1		0.(3)4114	0.(3)3673	0.(3)3732
1.57199*	3.76042*	1.11944*	1.07918*			4.61429*	4.56508*	4.57199*
0.45359	7000	16	14.583	1.2153	1	0.0005	0.(3)4464	0.(3)4536
1.65667*	3.84510*	1.20412*	1.16386*	0.08468*		4.69897*	4.64975*	4.65667*
907.18		32000	29167.	2430.6	2000	1	0.89286	0.90718
2.95770*		4.50515*	4.46489*	3.38570*	3.30103*		1.95078*	1.95770*
1016.1		35840	32667	2722.2	2240	1.12	1	1.0160
3.00691*		4.55437*	4.51410*	3.43492*	3.35025*	0.04922*		0.00691*
1000		35274	32151	2679.2	2204.6	1.1023	0.98421	1
3.00000*		4.54745*	4.50719*	3.42801*	3.34333*	0.04230*	1.99309*	

1 quarter = 28 lb avoirdupois. 1 pennyweight = 24 gr = 0.05 oz troy. 1 oz avoirdupois = 16 drams avoirdupois = 437.5 gr. 1 stone = 14 pounds. 1 cental = 100 pounds. 1 hundredweight = 112 pounds. 1 apothecaries' ounce = 8 apothecaries' drams = 24 scruples = 480 grains.

* Logarithm of the number immediately above.

41. Energy or Work

Joules = 10 ⁷ erg	Meter- kilograms	Foot-pounds	Kilowatt- hours	Cheval- vapeur- hours	Horse- power- hours	British thermal units
1	0.10197	0.73756	0.(6)27778	0.(6)37767	0.(6)37251	0.(3)9475
	1.00848*	1.86780*	7.44370*	7.57711*	7.57113*	4.97660*
9.80665	1	7.2330	0.(5)27241	0.(5)37937	0.(5)36530	0.009292
0.9915207*		0.85932*	6.43522*	6.56863*	6.56265*	3.96812*
1.3558	0.13826	1	0.(6)37662	0.(6)51206	0.(6)50505	0.001285
0.13220*	1.14068*		7.57590*	7.70932*	7.70333*	3.10880*
3.6 × 10 ⁶	3.6710 × 10 ⁵	2.6552 × 10 ⁶	1	1.3596	1.3410	3411.
6.55630*	5.56478*	6.42410*		0.13342*	0.12743*	3.53290*
2.6478 × 10 ⁶	270000	1.9529 × 10 ⁶	0.73550	1	0.98631	2509.
6.42288*	5.43136*	6.29068*	1.86658*		1.99401*	3.39948*
2.6845 × 10 ⁶	2.7375 × 10 ⁵	1.98 × 10 ⁶	0.74571	1.0139	1	2544.
6.42887*	5.43735*	6.29667*	1.87257*	0.00598*		3.40547*
1055.	107.6	778.4	0.02932	0.03986	0.03931	1
3.02340*	2.03188*	2.89120*	4.46710*	4.60051*	4.59453*	

* Logarithm of the number immediately above.

42. Pressure

Kilo-grams per sq cm	Pounds		Short tons, per sq ft	Atmos- pheres	Columns of mercury†		Columns of water†	
	Per sq in	Per sq ft			Meters	Inches	Meters	Feet
I	14.223	2048.2	1.0241	0.96781	0.73553	28.958	10.009	32.837
	1.15300*	3.31137*	0.01034*	1.98579*	1.86660*	1.46177*	1.00038*	1.51636*
0.070307	I	144	0.072	0.06804	0.051713	2.0359	0.70368	2.3087
2.84700*		2.15836*	2.85733*	2.83279*	2.71360*	0.30876*	1.84738*	0.36336*
0.(8)4882	0.006944	I	0.0005	0.(8)4725	0.(8)3591	0.014138	0.004887	0.016032
4.68863*	3.84164*		4.69897*	4.67442*	4.55524*	2.15040*	3.68901*	2.20500*
0.97648	13.889	2000	I	0.94504	0.71823	28.277	9.7734	32.065
1.98966*	1.14267*	3.30103*		1.97545*	1.85627*	1.45143*	0.99004*	1.50603*
1.0333	14.697	2116.3	1.0582	I	0.76	29.921	10.342	33.929
0.01421*	1.16722*	3.32558*	0.02955*		1.88081*	1.47598*	1.01459*	1.53058*
1.3596	19.338	2784.6	1.3923	1.3158	I	39.37	13.607	44.644
0.13340*	1.28640*	3.44476*	0.14373*	0.11919*		1.59517*	1.13378*	1.64976*
0.034533	0.49118	70.729	0.035365	0.033421	0.025400	I	0.34563	1.1340
2.53823*	1.69124*	1.84960*	2.54857*	2.52402*	2.40484*		1.53861*	0.05460*
0.099913	1.4211	204.64	0.10232	0.096697	0.073489	2.8933	I	3.2808
2.99962*	0.15262*	2.31099*	1.00996*	2.98541*	2.86622*	0.46139*		0.51598*
0.030453	0.43315	62.374	0.031187	0.029473	0.022399	0.88187	0.30480	I
2.48364*	1.63664*	1.79500*	2.49397*	2.46942*	2.35021*	1.94540*	1.48402*	

* Logarithm of the number immediately above.

† At 15° C. and $g = 980$.

43. Power

1 kilowatt = 1000 watts = 1000 joules per second.

1 horse-power = 550 foot-pounds per second.

1 cheval-vapeur = 75 kilogram-meters per second.

Kilowatts	Cheval- vapeur	Poncelet	Horse- power	M-kg per sec	Ft-lb per sec	Kg cal per sec	Btu per sec
I	1.3600	1.0197	1.341	101.97	737.5	0.2388	0.9475
	0.13341*	0.00848*	0.12743*	2.00848*	2.86780*	1.37803*	1.97660*
0.7355	I	0.75	0.9863	75	542.5	0.1756	0.6969
1.86659*		1.87506*	1.99402*	1.87506*	2.73438*	1.24456*	1.84318
0.980665	1.333	I	1.3151	100	723.3	0.2342	0.9292
1.99152*	0.12493*		0.11896*	2.00000*	2.85932*	1.36951*	1.96812*
0.7457	1.0139	0.7604	I	76.04	550	0.1780	0.7066
1.87257*	0.00599*	1.88104*		1.88104*	2.74036*	1.25055*	1.84916*
0.009807	0.01333	0.01	0.01315	I	7.233	0.002342	0.009292
3.99152*	2.12493*	2.00000*	2.11896*		0.85932*	3.36951*	3.96812*
0.001356	0.001843	0.00138	0.001818	0.1383	I	0.0003237	0.001285
3.13220*	3.26562*	3.14068*	3.25964*	1.14068*		1.51016*	3.10880*
4.188	5.694	4.271	5.616	427.1	3089	I	3.968
0.62201*	0.75542*	0.63049*	0.74945*	2.63049*	3.48984*		0.59861*
1.055	1.435	1.076	1.415	107.62	778.4	0.2520	I
0.02340*	0.15682*	0.03188*	0.15084*	2.03188*	2.89120*	1.40139*	

* Logarithm of the number immediately above.

44. Explanations

The preceding Tables give the numerical relations between different units of measure, all the numbers in one horizontal line being equivalents. For example, in Table 36 the first line shows that 1 meter is 39.37 inches, or 3.2808 feet, or 1.0936 yards, etc.; also the seventh line from the top shows that 1 yard is 0.9144 meters, or 36 inches, or 3 feet, or 4.545 links, or 0.1818 rods, etc.

When the notation $(^3)$ is seen it means that $(^3)$ is to be replaced by three ciphers; thus in the first line of Table 36 an equivalent of 1 meter is 0.0006214 statute miles and in Table 37 one square meter is 0.0000003861 square miles.

Below each equivalent is given its five-place logarithm marked with a *. These are useful in converting quantities of one unit into those of another unit. For example, to find how many feet there are in 69.39 nautical miles: Table 36 gives 6080.2 as the number of feet in one nautical mile, hence the required result is 69.39×6080.2 which may be found by ordinary multiplication; or by logarithms the log of 69.39 is taken from Table 30 while the log of 6080.2 is found from Table 36 as 3.78392; the addition of the two logs gives 5.62522 which is the log of 421910, where the fifth significant figure is liable to error; hence the probable result obtained from this table by use of the given logarithm is that 69.39 nautical miles are equivalent to 421910 ± 2.5 feet. By direct multiplication it is found that the number of feet is 421905.

Numbers in (**boldface type**) are exact values, while all others in the body of a table are liable to an error of one-fourth of a unit in the last significant figure. The equivalents above a table and many of those below it are also exact by definition. As a general rule results obtained by the use of equivalents or logarithms taken from the body of a table are liable to an error in the fifth significant figure, except when an equivalent in the heavy type is used directly.

Table 40 for measures of weight applies also to measures of

force when the engineers' system is used, since the unit of force is the force of gravity which acts on the unit of weight at latitude 45° on the surface of the earth.

Tables 41 and 43 contain some units which may not be familiar to students who use this book, but the time will come, if they enter on engineering work, when the equivalents of these tables may be of great value to them. Probably all, however, know the meanings of energy or work, of a horse-power and a kilowatt, and of a British thermal unit; concerning these a few exercises are given below.

45. Exercises

1. By Table 36 how many feet in one statute mile? how many meters in one kilometer? how many statute miles are equivalent to one nautical mile?

2. By Table 37 how many square feet in one acre? how many square meters are equivalent to one square inch? how many acres are equivalent to one square inch?

3. By Table 38 how many feet per minute are equivalent to one mile per hour? how many statute miles per hour are equivalent to one knot.

4. By Table 39 how many bushels are in one cubic yard? how many liquid gallons are in one cubic foot? how many liters are equivalent to 1000 liquid gallons?

5. By Table 40 how many grains in one avoirdupois pound? how many short tons in one long ton? how many kilograms in one metric ton?

6. By Table 41 how many kilowatt-hours are equivalent to 1 foot-pound? how many foot-pounds in one British thermal unit?

7. By Table 42 how many pounds per square inch are equivalent to one kilogram per square centimeter? how many feet of water will balance the pressure of one atmosphere?

8. By Table 43 how many foot-pounds per second make one horse-power? how many kilowatts are equivalent to 100 horse-powers?

9. How many meters are equivalent to 1000 feet? how many meters are equivalent to 300 yards? how many kilometers are equivalent to 62.2 statute miles?

10. How many acres are equivalent to 87,120 square feet? How many square meters are equivalent to 153,900 square inches?

11. How many U. S. liquid gallons are equivalent to 100,000 Imperial gallons? how many liters are equivalent to 624.3 cubic inches?

12. How many pounds avoirdupois are 1000 kilograms? how many long tons are 37.2 metric tons?

13. How many foot-pounds in 0.01 kilowatt-hours? How many horse-power-hours are equivalent to 6040 foot-pounds?

14. How many atmospheres will balance a column of water 68 feet high? how many inches of mercury will balance 100 atmospheres?

15. How many foot-pounds per second are equivalent to 100 horse-powers? how many horse-powers are equivalent to 55,000 foot-pounds per second?

16. How many inches in one meter? how many inches in one centimeter? how many pounds avoirdupois in 100 long tons and how many in one metric ton?

17. What is the definition of a horse-power? of a joule? of a British thermal unit? of a kilowatt-hour? of a horse-power-hour?

CHAPTER 7

MISCELLANEOUS TABLES

46. Mathematical Constants

Symbol	Number	Logarithm	Symbol	Number	Logarithm
π	3.1415927	0.4971499	$\sqrt{\pi}$	1.7724539	0.2485749
2π	6.2831853	0.7981799	$1/\sqrt{\pi}$	0.5641896	$\bar{1}.7514251$
3π	9.4247780	0.9742711	$\pi\sqrt{2}$	4.4428829	0.6476649
4π	12.5663706	1.0992099	$\sqrt{2\pi}$	2.5066282	0.3990899
5π	15.7079633	1.1961200	$\sqrt{\pi/2}$	1.2533141	0.0980599
6π	18.8495559	1.2753011	$\sqrt{2/\pi}$	0.7978844	$\bar{1}.9019401$
7π	21.9911486	1.3422479	ε	2.7182818	0.4342945
8π	25.1327412	1.4002399	ε^2	7.3890568	0.8685890
9π	28.2743339	1.4513924	$1/\varepsilon$	0.3678794	$\bar{1}.5657055$
$4\pi/3$	4.1877902	0.6220886	$1/\varepsilon^2$	0.1353353	$\bar{1}.1314110$
$\pi/2$	1.5707963	0.1961199	μ	0.4342945	$\bar{1}.6377843$
$\pi/4$	0.7853982	$\bar{1}.8950899$	$1/\mu$	2.3025851	0.3622157
$\pi/6$	0.5235988	$\bar{1}.7189986$	$\sin 1^\circ$	0.0174524	$\bar{2}.2418553$
$\pi/30$	0.1047198	$\bar{1}.0200286$	$\sin 1'$	0.0002909	$\bar{4}.4637261$
$\pi/180$	0.0174533	$\bar{2}.2418774$	$\sin 1''$	0.0000048	6.6855749
$1/\pi$	0.3183099	$\bar{1}.5028501$	2	2.	0.3010300
$2/\pi$	0.6366198	$\bar{1}.8038801$	$\sqrt{2}$	1.4142136	0.1505150
$180/\pi$	57.2957795	1.7581226	$\sqrt{1/2}$	0.7071068	$\bar{1}.8494850$
$10800/\pi$	3437.74677	3.5362739	3	3.	0.4771213
$648000/\pi$	206264.806	5.3144251	$\sqrt{3}$	1.7320508	0.2385606
π^2	9.8696044	0.9942997	$\sqrt{1/3}$	0.5773503	$\bar{1}.7614394$
$1/\pi^2$	0.1013212	$\bar{1}.0057003$			
π^3	31.0062767	1.4914496			
$1/\pi^3$	0.0322516	$\bar{2}.5085504$			

47. Decimal Equivalents of Common Fractions

Fract.	Decimal	Logarithm	Fract.	Decimal	Logarithm	Fract.	Decimal	Logarithm
$1/2$	0.5	$\bar{1}.69897$	$1/8$	0.125	$\bar{1}.09691$	$1/32$	0.03125	$\bar{2}.49485$
$1/3$	0.33333	$\bar{1}.52288$	$3/8$	0.375	$\bar{1}.57403$	$3/32$	0.09375	$\bar{2}.97197$
$2/3$	0.66667	$\bar{1}.82391$	$5/8$	0.625	$\bar{1}.79588$	$5/32$	0.15625	$\bar{1}.19382$
$1/4$	0.25	$\bar{1}.39794$	$7/8$	0.875	$\bar{1}.94201$	$7/32$	0.21875	$\bar{1}.33995$
$3/4$	0.75	$\bar{1}.87506$	$1/12$	0.08333	$\bar{2}.92082$	$9/32$	0.28125	$\bar{1}.44909$
$1/5$	0.2	$\bar{1}.30103$	$5/12$	0.41667	$\bar{1}.61979$	$11/32$	0.34375	$\bar{1}.53624$
$2/5$	0.4	$\bar{1}.60206$	$7/12$	0.58333	$\bar{1}.76592$	$13/32$	0.40625	$\bar{1}.60879$
$3/5$	0.6	$\bar{1}.77815$	$11/12$	0.91667	$\bar{1}.96211$	$15/32$	0.46875	$\bar{1}.67094$
$4/5$	0.8	$\bar{1}.90309$	$1/10$	0.0625	$\bar{2}.79588$	$17/32$	0.53125	$\bar{1}.72530$
$1/6$	0.16667	$\bar{1}.22185$	$3/10$	0.1875	$\bar{1}.27300$	$19/32$	0.59375	$\bar{1}.77360$
$5/6$	0.83333	$\bar{1}.92082$	$5/10$	0.3125	$\bar{1}.49485$	$21/32$	0.65625	$\bar{1}.81707$
$1/7$	0.14286	$\bar{1}.15490$	$7/10$	0.4375	$\bar{1}.64098$	$23/32$	0.71875	$\bar{1}.85658$
$2/7$	0.28571	$\bar{1}.45593$	$9/10$	0.5625	$\bar{1}.75012$	$25/32$	0.78125	$\bar{1}.89279$
$3/7$	0.42857	$\bar{1}.63202$	$11/10$	0.6875	$\bar{1}.83727$	$27/32$	0.84375	$\bar{1}.92621$
$4/7$	0.57143	$\bar{1}.75696$	$13/10$	0.8125	$\bar{1}.90982$	$29/32$	0.90625	$\bar{1}.95725$
$5/7$	0.71429	$\bar{1}.85387$	$15/10$	0.9375	$\bar{1}.97197$	$31/32$	0.96875	$\bar{1}.98621$
$6/7$	0.85714	$\bar{1}.93305$						

48. Natural Hyperbolic Functions

u	$\sinh u$	$\cosh u$	$\tanh u$	u	$\sinh u$	$\cosh u$	$\tanh u$
0.00	0.0000	1.0000	0.0000	2.25	4.6912	4.7966	0.9780
0.05	0.0500	1.0013	0.0500	2.30	4.9370	5.0372	0.9801
0.10	0.1002	1.0050	0.0997	2.35	5.1951	5.2905	0.9820
0.15	0.1506	1.0113	0.1489	2.40	5.4662	5.5569	0.9837
0.20	0.2013	1.0201	0.1974	2.45	5.7510	5.8373	0.9853
0.25	0.2526	1.0314	0.2449	2.50	6.0502	6.1323	0.9866
0.30	0.3045	1.0453	0.2913	2.55	6.3645	6.4426	0.9879
0.35	0.3572	1.0619	0.3364	2.60	6.6947	6.7690	0.9890
0.40	0.4108	1.0811	0.3800	2.65	7.0417	7.1123	0.9900
0.45	0.4653	1.1030	0.4219	2.70	7.4063	7.4735	0.9910
0.50	0.5211	1.1276	0.4621	2.75	7.7894	7.8533	0.9918
0.55	0.5782	1.1551	0.5005	2.80	8.1919	8.2527	0.9926
0.60	0.6367	1.1855	0.5370	2.85	8.6150	8.6728	0.9933
0.65	0.6967	1.2188	0.5717	2.90	9.0596	9.1146	0.9940
0.70	0.7586	1.2552	0.6044	2.95	9.5268	9.5791	0.9945
0.75	0.8223	1.2947	0.6352	3.00	10.018	10.068	0.9950
0.80	0.8881	1.3374	0.6640	3.05	10.534	10.581	0.9955
0.85	0.9561	1.3835	0.6911	3.10	11.076	11.122	0.9959
0.90	1.0265	1.4331	0.7163	3.15	11.647	11.690	0.9963
0.95	1.0995	1.4862	0.7398	3.20	12.246	12.287	0.9967
1.00	1.1752	1.5431	0.7616	3.25	12.876	12.915	0.9970
1.05	1.2539	1.6038	0.7818	3.30	13.538	13.575	0.9973
1.10	1.3356	1.6685	0.8005	3.35	14.234	14.269	0.9976
1.15	1.4208	1.7374	0.8178	3.40	14.965	14.999	0.9978
1.20	1.5095	1.8107	0.8337	3.45	15.734	15.766	0.9980
1.25	1.6019	1.8884	0.8483	3.50	16.543	16.573	0.9982
1.30	1.6984	1.9709	0.8617	3.55	17.392	17.421	0.9984
1.35	1.7991	2.0583	0.8741	3.60	18.285	18.313	0.9985
1.40	1.9043	2.1509	0.8854	3.65	19.224	19.250	0.9987
1.45	2.0143	2.2488	0.8957	3.70	20.211	20.236	0.9988
1.50	2.1293	2.3524	0.9052	3.75	21.249	21.272	0.9989
1.55	2.2496	2.4619	0.9138	3.80	22.339	22.362	0.9990
1.60	2.3756	2.5775	0.9217	3.85	23.486	23.507	0.9991
1.65	2.5075	2.6995	0.9289	3.90	24.691	24.711	0.9992
1.70	2.6456	2.8283	0.9354	3.95	25.958	25.977	0.9993
1.75	2.7904	2.9642	0.9414	4.0	27.290	27.308	0.9993
1.80	2.9422	3.1075	0.9468	4.1	30.162	30.178	0.9995
1.85	3.1013	3.2585	0.9518	4.2	33.336	33.351	0.9996
1.90	3.2682	3.4177	0.9562	4.3	36.843	36.857	0.9996
1.95	3.4432	3.5855	0.9603	4.4	40.719	40.732	0.9997
2.00	3.6269	3.7622	0.9640	4.5	45.003	45.014	0.9998
2.05	3.8196	3.9483	0.9674	4.6	49.737	49.747	0.9998
2.10	4.0219	4.1443	0.9705	4.7	54.969	54.978	0.9999
2.15	4.2342	4.3507	0.9732	4.8	60.751	60.759	0.9999
2.20	4.4571	4.5679	0.9757	4.9	67.141	67.149	0.9999

49. Napierian Logarithms of Numbers from 1 to 119

n	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	— ∞	0.0000	0.6931	1.0986	1.3863	1.6094	1.7918	1.9459	2.0794	2.1972
1	2.3026	2.3979	2.4849	2.5649	2.6391	2.7081	2.7726	2.8332	2.8904	2.9444
2	2.9957	3.0445	3.0910	3.1355	3.1781	3.2189	3.2581	3.2958	3.3322	3.3673
3	3.4012	3.4340	3.4657	3.4965	3.5264	3.5553	3.5835	3.6109	3.6376	3.6636
4	3.6889	3.7136	3.7377	3.7612	3.7842	3.8067	3.8286	3.8501	3.8712	3.8918
5	3.9120	3.9318	3.9512	3.9703	3.9890	4.0073	4.0254	4.0430	4.0604	4.0775
6	4.0943	4.1109	4.1271	4.1431	4.1589	4.1744	4.1897	4.2047	4.2195	4.2341
7	4.2485	4.2627	4.2767	4.2905	4.3041	4.3175	4.3307	4.3438	4.3567	4.3694
8	4.3820	4.3944	4.4067	4.4188	4.4308	4.4427	4.4543	4.4659	4.4773	4.4886
9	4.4998	4.5109	4.5218	4.5326	4.5433	4.5539	4.5643	4.5747	4.5850	4.5951
10	4.6052	4.6151	4.6250	4.6347	4.6444	4.6540	4.6634	4.6728	4.6821	4.6913
11	4.7005	4.7095	4.7185	4.7274	4.7362	4.7449	4.7536	4.7622	4.7707	4.7791

50. Multipliers for Transferring Logarithms

Common to Napierian			Napierian to Common		
1	2.302585093	Example.	1	0.434294482	Example.
2	4.605170186	Find Nap log of 105	2	0.868588964	Find number correspond
3	6.907755279	Com log 105 = 2.02119	3	1.302883446	ing to Nap log 1.6078
4	9.210340372	2 4.605170	4	1.737177928	.6 0.26058
5	11.512925465	.02 46052	5	2.171472410	07 304
6	13.815510558	I 2303	6	2.605766891	8 35
7	16.118095651	I 230	7	3.040061373	+0.26397
8	18.420680744	9 207	8	3.474355855	—0.43429
9	20.723265837	Nap log 105 = 4.65396	9	3.908650337	Com log = 1.8297
					Number = 0.6756

51. Explanations

Table 46 gives seven-place constants and their logarithms which will often be of use in mathematical computations; π is the ratio of the circumference of a circle to its diameter, e is the base of the Napierian system of logarithms, and μ is the modulus of the common system of logarithms. In this table the shilling mark / denotes division; thus, $\pi/30$ is the same as $\frac{1}{30}\pi$.

Table 47 gives decimal equivalents of some common fractions, thus, $7/32 = 0.21875$. The logarithms may be useful in computations; thus to divide 0.3275 by $13/16$ the log of $13/16$ is subtracted from the log of 0.3275, or $1.51521 - 1.90982 = 1.60539$ which is the log of 0.4031.

Table 48 gives natural hyperbolic sines, cosines and tangents of numbers. These are useful in engineering problems relating to beams, to the catenary, the parabola, and other curves, also in the theory of alternating currents. Hyperbolic functions can be graphically represented in a rectangular hyperbola in the same way as trigonometric functions are represented in a circle. "Sinh" is the abbreviation for the hyperbolic sine, and "cosh" for the hyperbolic cosine; \sinh is usually pronounced *shin*.

Table 49 gives a few Napierian logarithms, often called hyperbolic logarithms. The base of this system is the number 2.71828. Such logarithms arise in many formulas deduced by calculus, and they are widely used in physical and engineering problems. Table 50 shows how to obtain the Napierian logarithm of any number from its common logarithm.

51. Exercises

1. Divide 4738 by π , using logarithms.
2. What is the value of $4\pi^2$?
3. What is the meaning of $180^\circ/\pi$?
4. What is the area of a sphere whose radius is 100 feet?
5. What is the volume of a sphere whose diameter is 10 centimeters?
6. Find the value of $472/\sqrt{\frac{1}{3}}$.
7. What are the decimal equivalents of $2/7$, $11/32$, $80/32$, $7/12$, $9/12$, $34/64$, and $35/64$?
8. Given $u=1.25$; square $\sinh u$ and $\cosh u$ and subtract the first square from the second. Also do the same for another value of u .
9. Is $\tanh u$ equal to $\sinh u/\cosh u$?
10. Multiply 37 by 8, using Napierian logarithms.
11. Divide 119 by 17, using Napierian logarithms.
12. Taking the common logarithm of e from Table 47, find the value of e^5 .
13. If the common logarithm of a number is 4.0000, what is its Napierian logarithm?
14. Find the Napierian logarithm of 2.718284.
15. Find the Napierian logarithms of 3275, 3.275, 1800, and 0.18

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